AgRISTARS

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Inventory Technology Development

A Joint Program for Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing

April 15, 1982

SEMI-ANNUAL PROGRAM REVIEW PRESENTATION TO LEVEL 1, INTERAGENCY COORDINATION COMMITTEE

Lyndon B. Johnson Space Center
Houston, Texas 77058

THIS IS THE FIFTH SEMI-ANNUAL PRESENTATION OF THE INVENTORY TECHNOLOGY DEVELOPMENT (ITD) PROJECT STATUS TO AGRISTARS LEVEL 1, INTERAGENCY COORDINATION COMMITTEE ON APRIL 19-20, 1982. IT REPRESENTS ACCOMPLISHMENTS FROM OCTOBER 1, 1981 THROUGH MARCH 30, 1982.

JON D. ERICKSON
ITD PROJECT MANAGER

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OVERVIEW OF AN EXTREMELY SUCCESSFUL FCPF PERIOD (APRIL-SEPTEMBER 1981)

- FCPF DEVELOPED PROCEDURES WERE SHOWN IN PILOT TESTS
  - TO BE HIGHLY EFFICIENT ("USER ACCEPTABLE") WHILE PRODUCING POST-HEADING U.S./CANADIAN SSG'S CROP ESTIMATES WITH ACCURACIES (WITHIN 3-1/2 TO 9% OF USDA) COMPARABLE TO THE BEST PREVIOUS SSG'S PROCEDURE.
  - TO PRODUCE ACCURATE POST-TASSELING SUMMER CROP ESTIMATES IN CENTRAL U.S. CORN BELT WITH SIGNIFICANT BIAS FOR CORN AND SOYBEANS ONE OF TWO YEARS.
- PROGRESS IS BEING MADE ON KEY TECHNICAL PROBLEMS
  - MODELING OF CROP SIGNATURES (SPATIAL/SPECTRAL/MULTI-TEMPORAL)
  - TREATMENT OF BOUNDARY PIXELS
  - ASSESSMENT OF LONG-TERM EFFECTS OF CLOUD COVER AND SATELLITE FREQUENCY
  - YEAR-TO-YEAR AREA CHANGE DETECTION METHODOLOGY
  - FOREIGN PERFORMANCE PREDICTION MODELING AND SIMULATION
- IMPORTANT UNDERSTANDING OF FOREIGN CROP REGIONS BEING OBTAINED FOR
  - AUSTRALIA
  - ARGENTINA
  - BRAZIL

OVERVIEW OF ITD ACCOMPLISHMENTS AND CHANGES
(OCTOBER 1981-MARCH 1982)

- ITD CONTINUED TO BUILD ON ACCOMPLISHMENTS OF PREVIOUS PERIOD
  - FURTHER QUANTIFIED MAJOR SOURCE OF SSG ERRORS TO BE IN ACQUISITION SELECTION - ASSOCIATED WITH SATELLITE OVERPASS FREQUENCY AND CLOUD COVER.
  - SIGNIFICANT IMPROVEMENT MADE IN ACCURACY AND EFFICIENCY OF POST-TASSELING CORN AND SOYBEANS PROCEDURES.
  - BEGAN TO EXTEND TECHNOLOGY TO INCLUDE WINTER SMALL GRAINS FOR USSR APPLICABILITY.
- PROGRESS CONTINUES TO BE MADE ON KEY TECHNICAL PROBLEMS.
- PROMISING PRELIMINARY RESULTS HAVE BEEN OBTAINED FOR NEW APPROACHES TO AREA ESTIMATION
  - EARLY SEASON
  - CHANGE ESTIMATION
- THE GOALS OF FOREIGN APPLICABLE TECHNOLOGY AND UNDERSTANDING TO SUPPORT SATELLITE AND SENSOR SYSTEMS DEFINITION HAVE BEEN RETAINED.
- TESTING OVER REGIONS AND YEARS OF SIGNIFICANT VARIABILITY, WHICH WAS BELIEVED TO BE IMPORTANT TO UNDERSTANDING THE DIRECTION OF RELIABLE TECHNOLOGY DEVELOPMENT, HAS BEEN RELUCTANTLY DELETED.

ITD FY82
SUMMARY ACCOMPLISHMENTS
(OCT 1, 1981 TO MARCH 31, 1982)

CROP ID/LABELING/PROPORTION ESTIMATION TECHNOLOGY DEVELOPMENT

- SMALL GRAINS

  + SENSITIVITY STUDIES OF SSG 3B/3C AND SSG4 IN PROGRESS

    - QUANTIFIED IMPACT OF ACQUISITION SELECTION AND SSG3B/C PERFORMANCE
      . IMPROVED ACQUISITION SELECTION DECREASED MAE FROM 8.5% TO 5.1% AND INCREASED R^2 FROM .68 TO .89 RELATIVE TO GROUND TRUTH PROPORTIONS. R^2 FOR PROBLEM YEAR (1979) INCREASED FROM .35 TO .79
      . PROCESSABILITY UNCHANGED (REMAINS HIGH 58%)
    - QUANTIFIED IMPACT OF MINOR SOFTWARE PROBLEMS ON SSG4 TEST RESULTS
      . DECREASE MAE FROM 8.7% TO 8.4% AND R^2 FOR PROBLEM YEAR 1979 INCREASED FROM .41 TO .68.
      . EFFECT OF IMPROVED ACQUISITION SELECTION ON SSG4 NOT STUDIED, BUT ASSUMED TO BE SIMILAR TO SSG 3B/C
    - DATA BASES FOR 2 REMAINING SENSITIVITY STUDIES COMPLETE
      . DETAILED LABELING STUDIES
      . 4 PROCEDURE AGGREGATION STUDY (ALL 32 AGGREGATIONS COMPLETED)
    - ALL OTHER PLANNED SENSITIVITY STUDIES DELETED

CROP ID/LABELING/PROPORTION ESTIMATION TECHNOLOGY DEVELOPMENT (CONTINUED)

- SMALL GRAINS
  - + DEVELOPED INITIAL APPROACH AND COMPLETED FEASIBILITY TESTS FOR AN EARLY SEASON (PRE-TILLERING) DIRECT SPRING SMALL GRAINS PROPORTION ESTIMATOR (SSG5)
    - 45 SEGMENTS OVER 3 YEARS (76, 78, 79)
    - PERFORMANCE CHARACTERISTICS COMPARABLE WITH AT HARVEST RESULTS, OBTAINED IN SPRING SMALL GRAINS PILOT (RME = 4.9%, STANDARD DEV. = 9.1%, R^2 = .68)
    - APPROACH AMENABLE TO CURRENT FCCAD ENVIRONMENT
  - + INITIATED DEVELOPMENT OF SG1 AND MC3 - EXTENSIONS OF THE PREVIOUSLY REPORTED SSG3 AND SSG4 AUTOMATED LABELING AND PROPORTION ESTIMATION PROCEDURE TO INCLUDE WINTER SMALL GRAINS.

CROP ID/LABELING/PROPORTION ESTIMATION TECHNOLOGY DEVELOPMENT (CONTINUED)

- CORN/SOYBEANS/SUMMER CROPS
  - + C/S 1B - A SEMIAUTOMATED ERIM EXTENSION OF C/S 1
    - (78-79) DEFINITION TEST (20 SEGMENTS) INDICATED DESIRED ACCURACY IMPROVEMENTS
    - 1980 SENSITIVITY TEST (IOWA-69 SEGMENTS, 27 WITH GT) RESULTS WITHIN 11% RME FOR CORN, SOYBEANS AND SUMMER CROPS (STANDARD ERROR ALSO LOW: 3 TO 9%)
    - EFFICIENCY MUCH IMPROVED
    - PROCESSABILITY REMAINS HIGH (64%)
    - AUTOMATION OF REMAINING STEPS IN DEVELOPMENT
    - EVALUATION OF ALTERNATIVE LABELING TARGET DEFINITION (BLOB DOT RELOCATION, MIXTURE DECOMPOSITION) UNDERWAY

CROP ID/LABELING/PROPORTION ESTIMATION TECHNOLOGY DEVELOPMENT (CONTINUED)

- CORN/SOYBEANS/SUMMER CROPS (CONTINUED)
  - + MC2B - FULLY AUTOMATED (LEMSCO) ADAPTATION OF SSG 4 TYPE TECHNOLOGY
    - 78-79 DEFINITION TEST COMPLETE
    - 1980 SENSITIVITY TEST (IOWA) RESULTS SHOWED LARGE SUB-REGIONAL BIAS PREVIOUSLY UNDETECTED IN 78-79 RESULTS
  - + SEMIAUTOMATED CS1B TECHNOLOGY SELECTED FOR FURTHER (ILLINOIS, INDIANA 1980 DATA) SENSITIVITY TESTING
  - + CONDUCTED AN ASSESSMENT OF SR CS4 TECHNOLOGY IMPLEMENTATION STATUS AND RECOMMENDED ISSUES TO SR FOR RESOLUTION

CROP ID/LABELING/PROPORTION ESTIMATION TECHNOLOGY DEVELOPMENT (CONTINUED)

- LARGE UNIT PROPORTION ESTIMATION
  - + ALTERNATE APPROACH BEING INVESTIGATED
    - BASED ON SSG 4 TYPE TECHNOLOGY EXTENDED TO AGRICULTURAL REGIONS (RATHER THAN FIELDS) FOR WINTER/SPRING SMALL GRAINS AND SUMMER CROPS
    - APPROACH AMENABLE TO CURRENT FCCAD ENVIRONMENT
      - . PRECISE REGISTRATION NOT REQUIRED
      - . USES SKIP SAMPLED FULL FRAME DATA

FEATURE IDENTIFICATION/SIGNATURE CHARACTERIZATION

- SMALL GRAINS
  - + SPECTRAL AND METEOROLOGICAL DATA SETS DEFINED FOR AUSTRALIA AND USSR RESEARCH
    - GROUND TRUTH FROM 2 CROP YEARS NOW AVAILABLE FOR AUSTRALIA (ALSO SELECTED OBS FROM 2 OTHER YEARS)
  - + FSR DATA SETS SELECTED FOR SG1 AND MC3 DEVELOPMENT
  - + SOFTWARE DEVELOPED TO FIND EXPECTED TEMPORAL/SPECTRAL CROP SIGNATURES AND THEIR VARIANCES

FEATURE IDENTIFICATION/SIGNATURE CHARACTERIZATION (CONTINUED)

- CORN/SOYBEANS
  - + INVESTIGATION ACCOMPLISHED FROM SR FIELD MEASUREMENTS DATA BASE ON RELATIONSHIP OF CORN AND SOYBEANS PROFILE FEATURES TO CROP DEVELOPMENT STAGE CULTURAL FEATURES, AND STRESS (ERIM)
    - CORN EXHIBITS A GREENNESS PLATEAU DURING THE CROP YEAR NOT SEEN IN SOYBEANS OR SMALL GRAINS
    - CORN ACHIEVED PEAK GREENNESS PRIOR TO PEAK LAI, TASSELING. EXPLAINABLE BY CANOPY STRUCTURE
    - SOYBEAN PROFILE FEATURES MORE CORRELATED WITH CANOPY CLOSURE THAN VEGETATIVE STAGES. THIS IS PROBABLY DUE TO INDETERMINATE NATURE OF PLANT REPRODUCTIVE CYCLE.
  - + EXCELLENT DISCRIMINATION BETWEEN CORN AND SOYBEANS ACHIEVED BY USE OF A PEAK GREENNESS FEATURE AND THE PLATEAU IN GREENNESS OF CORN (FIELD MEASUREMENT DATA)
    - ANALYSIS OF EXTENSION TO LANDSAT MSS INITIATED
  - + EXAMINATION OF LIMITED U.S. DATA INDICATES RELATIVE BRIGHTNESS APPEARS TO PLAY IMPORTANT ROLE IN SUNFLOWER SEPARABILITY (UCB)
    - ARGENTINA LANDSAT AND GROUND DATA NOW AVAILABLE FOR STUDY.

- AREA CHANGE ESTIMATION METHODOLOGY

  + COMPLETED PRELIMINARY STUDY/ANALYSIS IN USSR INDICATING THE LEVEL OF PERFORMANCE (VARIANCE) IN CHANGE ESTIMATION AS A FUNCTION OF SAMPLE SIZE

    - APPROACH TAKES ADVANTAGE OF YEAR-TO-YEAR CORRELATION
    - APPROXIMATELY 25% TO 30% REDUCTION IN NUMBER OF REQUIRED SEGMENTS FOR CHANGE ESTIMATOR

  + DEVELOPED PROFILE CHANGE APPROACH

    - APPROACH MEASURES YEAR-TO-YEAR CHANGE IN VEGETATIVE AREA TO ESTIMATE CROP AREA
    - INITIAL FEASIBILITY STUDY ENCOURAGING: COMPARISON WITH SSG 4 OVER 9 COMMON SEGMENTS INDICATED MEAN ERROR IN ESTIMATED CHANGE REDUCED FROM +6.2% TO -1.2%; STANDARD DEVIATION REDUCED FROM 16.1% TO 3.6%.

- SAMPLING AND AGGREGATION TECHNOLOGY DEVELOPMENT

  + INITIATED EVALUATIONS OF ADVANCED AGGREGATION TECHNOLOGIES (FOUR AGGREGATION PROCEDURES.
    - SINGLE YEAR VS. MULTIYEAR; SIMPLE RATIOING FOR MISSING STRATA VS. MATHEMATICALLY OPTIMAL ADJUSTMENT
    - AGGREGATIONS COMPLETED. EVALUATIONS UNDERWAY

  + DEVELOPED PARTIAL RESPONSE MODEL (TAMU)
    - ALLOWS AGGREGATION OF SEGMENTS HAVING CROP GROUP ESTIMATES WITH THOSE HAVING CROP TYPE ESTIMATES
    - RECOVERS APPROXIMATELY 50% OF THE VARIANCE INCREASE PREVIOUSLY DUE TO DELETION OF CROP GROUP ONLY ESTIMATES
    - COMPLETION OF VARIANCE ESTIMATOR DELAYED

  + INITIATED INVESTIGATION OF A PROCEDURE FOR AUTOMATED DYNAMIC STRATIFICATION ORIENTED TO DETECTION OF CHANGE AND CONDITION ASSESSMENT.

- FUTURE SATELLITE AND SENSOR SYSTEM DEFINITION

  + AGRICULTURE INFORMATION SYSTEM SIMULATOR
    - COMPLETED DEFINITION TESTING OF ACQUISITION HISTORY SIMULATION MODULE
      . TESTED OVER U.S. NORTHERN GREAT PLAINS FOR 76-77
      . 143 SEGMENT/LOCATIONS
      . SIMULATION APPEARS HIGHLY REALISTIC
    - INITIATED DEVELOPMENT OF SEGMENT LEVEL PROPORTION ESTIMATION AND PROPORTION ESTIMATION ERROR SIMULATION MODULES
    - DELETED DEVELOPMENT OF SEGMENT LEVEL MSS SIMULATOR

  + MULTI-SATELLITE/SENSOR INFORMATION CONTENT SIMULATOR
    - IN USE TO INVESTIGATE COMBINATIONS OF ORBITS/SENSORS BEST SUITED TO DETECT AND QUANTIFY AGRICULTURAL PARAMETERS (ERIM)

  + PREPARED AND SUBMITTED TM PROPOSAL, PARTICIPATED IN APPLICATIONS NOTICE PROPOSAL EVALUATIONS AND SCOPED ITD TM DATA REQUIREMENTS

  + FORMED ITD LANDSAT-D WORKING GROUP (JSC/ERIM/UCB/LEMSCO) TO DEVELOP IMPLEMENTATION PLAN FOR ERAD LANDSAT-D/TM PROPOSAL

- FUTURE SATELLITE AND SENSOR SYSTEM DEFINITION (CONTINUED)

  + EXPLORATION OF COMBINED LANDSAT/SEASAT USE FOR CROP INVENTORY UNDERTAKEN (ERIM)

    - SCIENTIFIC BREAKTHROUGH IN REMOVAL OF SPECKLE FROM SAR DIGITAL DATA

    - ARTIFICIAL INTELLIGENCE APPROACH USED TO DETERMINE KEY RADAR FEATURES
      . FEATURES CALLED TONE AND TEXTURE FOUND TO BE CORRELATED TO CORN AND SOYBEAN CANOPY STRUCTURAL FEATURES
      . TECHNICAL BREAKTHROUGH IN ABILITY TO EXTRACT TEXTURE INFORMATION WITHOUT LOSS OF SPATIAL RESOLUTION

    - COMBINED LANDSAT/SEASAT DATA PERMIT CORN/SOYBEAN DISCRIMINATION 6 WEEKS PRIOR TO DISCRIMINATION WITH LANDSAT ALONE

  + CONDUCTED A PRELIMINARY SHUTTLE IMAGING RADAR-A (SIR-A) ANALYSIS IN AUSTRALIA AND COLLECTED COMPLEMENTARY GROUND OBSERVATIONS.
    - SIGNIFICANT AGRICULTURE INFORMATION APPARENT, FURTHER STUDY PLANNED.

- FUTURE SATELLITE AND SENSOR SYSTEM DEFINITION (CONCLUDED)

  + INITIATED INVESTIGATION OF USE OF ENVIRONMENTAL SATELLITE TYPE DATA FOR AREA ESTIMATION (COORDINATED WITH NOAA LIAISON MANAGER AND EW PERSONNEL)

    - FREQUENT COVERAGE MAY BE ADVANTAGE IN ESTIMATION OF CROP EMERGENCE AND CHANGE DETECTION

    - FOR USE IN CONJUNCTION WITH LANDSAT DATA

  + FUNDING PROPOSALS HAVE BEEN SUBMITTED TO EVALUATE LARGE FORMAT CAMERA (LFC) AND SIR-B (OSTA-3, 1984) IN AGRICULTURE CONTEXT (ITD BENEFITING)

    - ASSESS ROLE OF HIGH SPATIAL RESOLUTION DATA

    - FURTHER ASSESS RADAR ALL-WEATHER AND DAY-NIGHT BENEFITS

DATA AND DATA SYSTEMS

+ CONDUCTED AN ANALYSIS AND DEVELOPED REQUIREMENTS FOR SAMPLE SEGMENT AND PIXEL SIZE FOR THE JSC EXTRACTION AND REGISTRATION OF 1981 LANDSAT DATA FROM THE GSFC MDP

+ CONDUCTED STUDY TO VERIFY TEST STATISTICS ASSOCIATED WITH USING 3 BY 6 N. MILE GROUND TRUTH WITH 5 BY 6 N. MILE PROPORTION ESTIMATES ARE ACCEPTABLE FOR 1980 CENTRAL CORN BELT DATA ANALYSIS

+ SCREENED 1980 CROP YEAR IMAGERY (U.S.) AND PREPARED IMAGE QUALITY DATA BASE

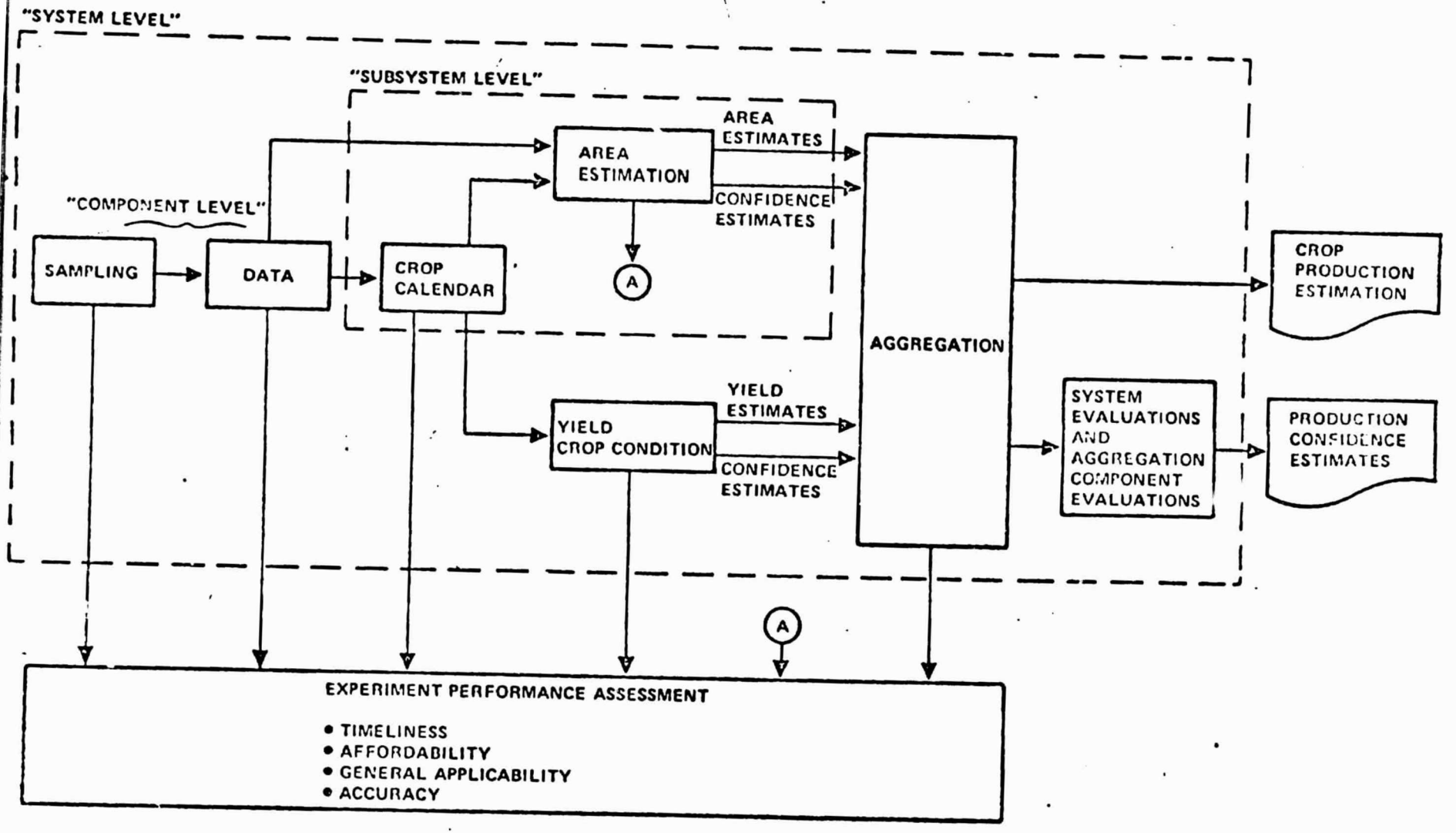
+ DIGITIZED CROP YEAR 1981 GROUND TRUTH (GT) DATA FOR 16 ARGENTINA SITES AND TRANSMITTED TO INVESTIGATORS AT JSC AND UCB (ERIM)

+ RECEIVED AUSTRALIAN GT (20 SEGMENTS). CURRENTLY EXTRACTING LANDSAT DATA AND DIGITIZING GT

+ OBTAINED AUSTRALIAN COOP MET DATA SET
  - 3 YEARS (78-80)
  - INCREASED STATION DENSITY/COVERAGE (500 COOP VS 25 SYNOPTIC)
  - COVERAGE OF INTERIOR IN ADDITION TO COASTAL REGIONS

INVENTORY TECHNOLOGY DEVELOPMENT

AGRICULTURE INFORMATION SYSTEM CONCEPT



ITD "SYSTEM" CONCEPT

WHAT IT IS NOT!

- A HARDWARE/SOFTWARE SYSTEM FOR DELIVERY.
- THE DESIGN OF A USER OPERATIONAL SYSTEM.

WHAT IT IS!

- A WAY TO ORGANIZE THE "TECHNOLOGY" INTO FUNCTIONAL RELATIONS AND AN INTEGRATED CONTEXT THAT ENABLES RESEARCH AND EVALUATION TO ACCOMPLISH NECESSARY ACTIVITIES.

  -- A MAJOR BENEFIT FROM THE RESEARCH QUALITY DATA BASE AND AND THE EFFICIENCY PROVIDED BY THE AUTOMATED PROCEDURES IS THE RAPID FEEDBACK OF PERFORMANCE RESULTS TO PROCEDURAL DEVELOPMENT.

  -- NOW IT IS POSSIBLE TO VARY THE SUB-COMPONENT WITHIN THE ARCHITECTURE OF THE PROCEDURE AND DETERMINE THE EFFECTS OF THIS CHANGE ON SUB-SYSTEM OR COMPONENT PERFORMANCE ACCURACY, EFFICIENCY, OBJECTIVITY, ETC.

- REPORTING
  - PREPARED INPUTS FOR AGRISTARS ANNUAL REPORT
  - TWO PAPERS PRESENTED AT ANNUAL MEETING OF AMERICAN SOCIETY OF AGRONOMY
  - ABSTRACTS SUBMITTED FOR PAPERS AT SEVERAL UPCOMING SYMPOSIA
    - INTERNATIONAL SOCIETY FOR PHOTOGRAMMETRY AND REMOTE SENSING
    - SIXTEENTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT
    - EIGHTH INTERNATIONAL SYMPOSIUM ON MACHINE PROCESSING OF REMOTELY SENSED DATA
    - AMERICAN STATISTICAL SOCIETY ANNUAL MEETING
    - TWO PAPERS TO BE PRESENTED AT HOUSTON CHAPTER OF AIAA
  - ITD QUARTERLY TECHNICAL INTERCHANGE MEETING HELD AT JSC MARCH 24, 25
  - 23 PROJECT REPORTS PREPARED

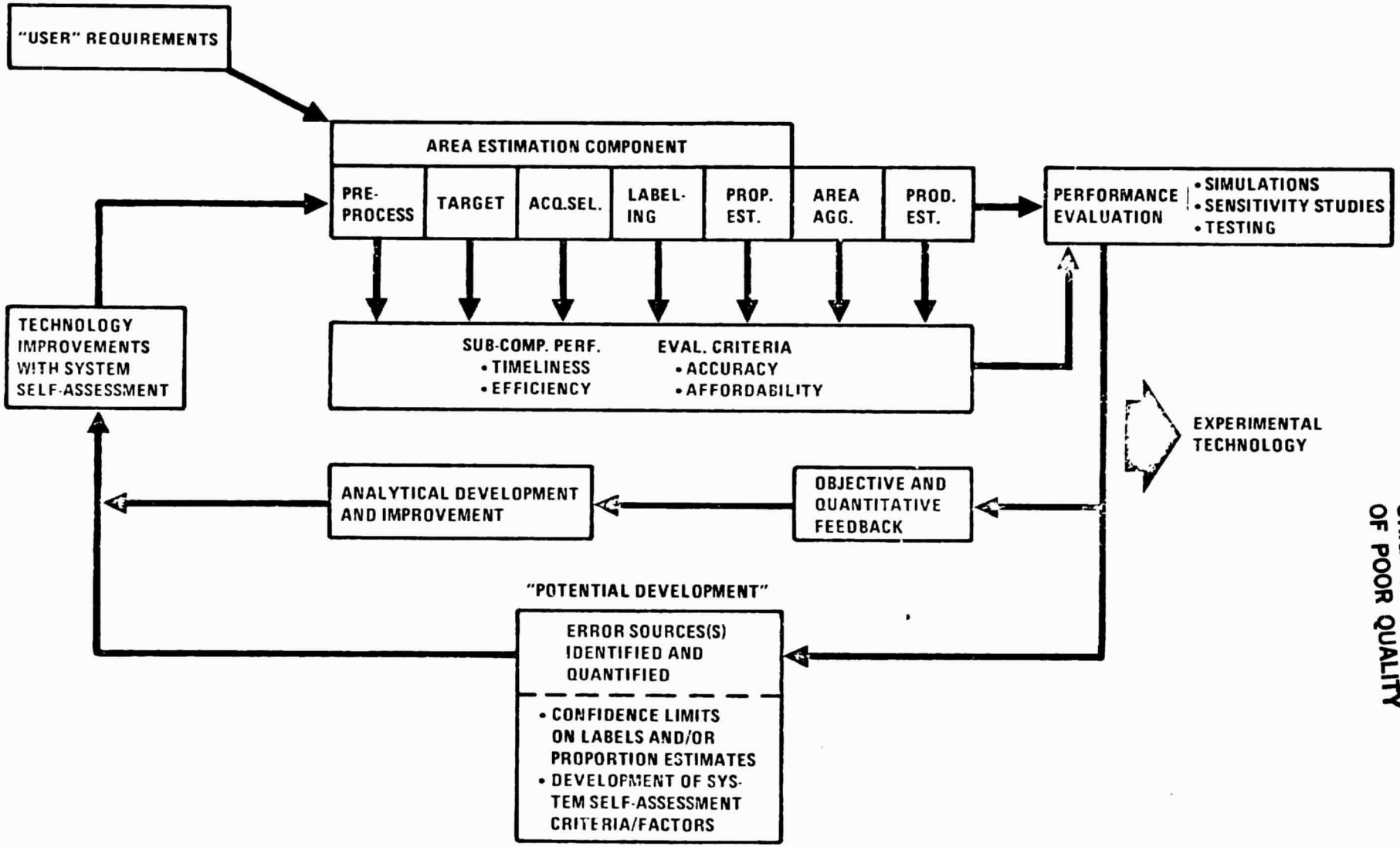
NEW RESULTS IN THE DEVELOPMENT OF SMALL GRAINS (SSG3) AND CORN/SOYBEANS (CS1) AREA ESTIMATION TECHNOLOGY

R. M. BIZZELL
4-19-82

PRESENTATION ITEMS

- TECHNOLOGY DEVELOPMENT OVERVIEW
- SPRING SMALL GRAINS DEVELOPMENT/RESULTS
- CORN/SOYBEANS DEVELOPMENT/RESULTS
- SUMMARY

TECHNOLOGY DEVELOPMENT OVERVIEW



SPRING SMALL GRAINS DEVELOPMENT/RESULTS

- RESULTS FROM FY81 PILOT EXPERIMENT WITH THE AUTOMATED TECHNOLOGIES SUFFICIENTLY ENCOURAGING TO WARRANT CONTINUATION OF THIS (SSG-3) AREA ESTIMATION TECHNOLOGY DEVELOPMENT
  - + IDENTIFICATION AND QUANTIFICATION OF MAJOR SUBCOMPONENT ERROR SOURCES CONTINUING. PRELIMINARY FEEDBACK INDICATES:
    - + ACQUISITION SELECTION/DESIGNATION MAJOR CONTRIBUTOR TO THE ERROR
    - + INCORRECT IMPLEMENTATION OF A SUBCOMPONENT MODULE (SOFTWARE)
    - + INFLUENCE OF BOUNDARY/MIXED PIXELS ON PROPORTION ESTIMATION VARIANCE
  - + ACQUISITION SELECTION/DESIGNATION PROBLEM VERIFIED BY A SUBSEQUENT STUDY AND EVALUATION
- RESEARCH STUDIES TO DEFINE SOLUTIONS TO THE ACQUISITION SELECTION AND BOUNDARY/MIXED PIXELS HAVE BEEN INITIATED.

SPRING SMALL GRAINS TECHNOLOGY DIFFERENCES

FUNCTION	"SPECTRAL SEQ. LOGIC" SSG3B	"SPECTRAL SEQ. LOGIC" SSG3C	"COLOR SEQ. METHOD" SSG4	"CLUSTERING SPECTRAL SEQ. LOGIC" SSG2
• SAMPLING				
+ Target	+ Pixels	+ Pixels	+ Quasi-fields	+ Pixel
+ Method of selection	+ Systematic sample	+ Systematic sample	+ All quasi-fields	+ Bayesian selection
• LABELER				
+ Acquisition selection	+ Analyst verification	+ Automated (biowindow midpoint model)	+ Automated (biowindow duration model)	+ Analyst verification
+ Decision logic	+ Hierarchical selection	+ Hierarchical selection	+ Table look-up (binary)	+ Hierarchical selection
- Vegetative index number	- Kauth-Thomas transformation	- Kauth-Thomas transformation	- Normalized channel rankings	- Kauth-Thomas transformation
• PROPORTION ESTIMATION				
+ Sample size	+ 836 pixels	+ 836 pixels	+ All quasi-fields	+ 60 pixels
+ Method of estimation	+ Relative count	+ Relative count	+ Enumeration with adjustment	+ Bayesian proportion estimation

ERROR CHARACTERIZATION STUDIES

(1.) OUTLIER EXAMINATION STUDY SUMMARY *

- EXAMINE THE SEGMENTS WITH THE LARGEST ERRORS FOR EACH PROCEDURE
  - DUE TO TIME CONSTRAINTS, ONLY 20 SEGMENTS WERE EXAMINED FOR EACH PROCEDURE
  - NOT ABLE TO QUANTIFY THE EFFECTS OF THE OBSERVED CAUSES FOR ALL SEGMENTS
  - PROVIDES QUICK, EFFICIENT FEEDBACK ON MAJOR SOURCES OF ERROR

ERROR SOURCE	SSG4	SSG3B	SSG3C
CLERICAL/SOFTWARE	9	2	1
BIOWINDOW DEFINITION	4	17	19
PROCEDURE DEFICIENCY/ UNKNOWN	7	1	0

- BIOWINDOW (CROP SPECTRAL APPEARANCE) DESIGNATION MODEL DRIVEN BY TEMPERATURE IS THE LARGEST SINGLE SOURCE OF ERROR

* FROM SEMI-ANNUAL PROJECT MANAGEMENT REPORT, NOV. 1981

TEST NO.	TEST TYPE	CROP PROCEDURE/NAME	PROC. TYPE	TEST LEVEL	TEST REGION	SEGS.	YEAR(S)	DATE	TEST PERIOD	
									FROM	TO
12	PILOT	SSG2 - BASELINE SSG3B - SEMI AUTO. CAESAR SSG3C - AUTOMATIC CAESAR SSG4 - SPATIAL/COLOR SEQUENCE	AREA ESTIMATION	SUBSYSTEM	US/CANADA	189	76-79	9/28/81	8/81	9/81
CHARACTERIZATION OF SSG'S PROPORTION ESTIMATION ERRORS										

RESULTS SSG3B (CONTINUED)

4. BIOWINDOW DESIGNATION ERROR

INCORRECT ACQUISITION SELECTION

SEGMENT	YEAR	STATE	ERROR
1920	1979	ND	40.1
1918	1979	ND	34.4
3050	1979	SK	29.0
1392	1979	ND	28.5
1556	1977	MT	24.4
1903	1977	ND	23.0
1924	1978	ND	-22.7
1457	1978	ND	-22.6
1524	1976	MN	22.3
1633	1976	ND	21.9
1461	1979	ND	20.0
1825	1978	MN	-19.4
1614	1976	ND	18.5
1807	1977	SD	-17.4
1461	1978	ND	16.9
1514	1978	MN	16.3
1909	1978	ND	-15.9

"Extracted From Semi-Annual Project Management Report November 1981"

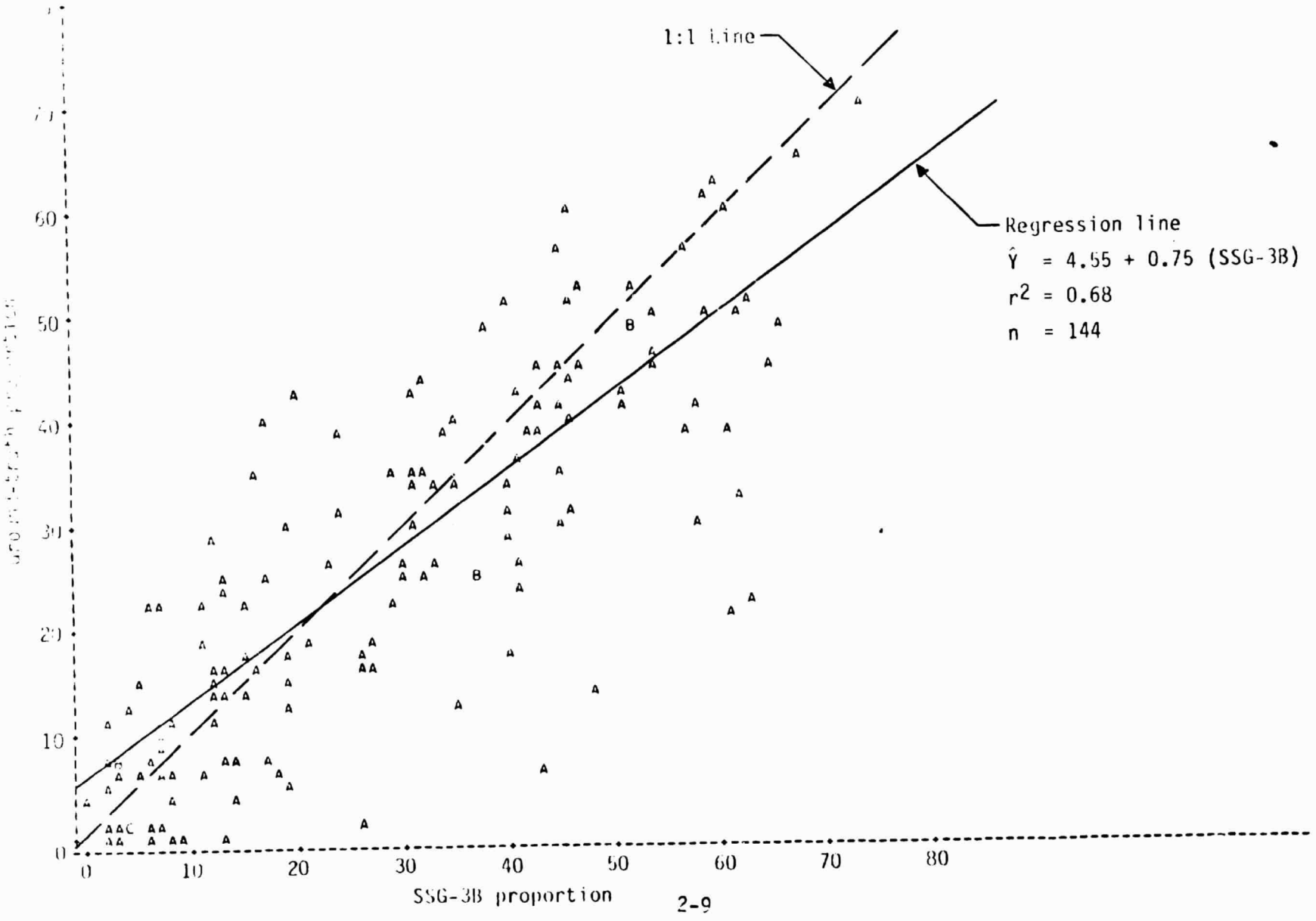
VALIDATION OF ACQUISITION SELECTION/DESIGNATION FOR SSG-3 FROM FY '81 PILOT EXPERIMENT

STATISTIC	ALL YEARS		1976		1977		1978		1979	
	SSG-3B	SSG-3B1*	SSG-3B	SSG-3B1*	SSG-3B	SSG-3B1*	SSG-3B	SSG-3B1*	SSG-3B	SSG-3B1*
e	3.01	1.36	5.62	3.98	2.12	2.30	0.04	-0.59	7.71	1.17
S_e	11.31	6.19	6.72	4.13	9.51	5.54	11.12	6.46	16.23	7.46
MAE	8.49	5.14	6.16	4.54	7.73	4.99	8.44	5.19	12.66	6.07
RME	11.51	5.16	24.10	16.80	8.20	8.65	0.15	-2.27	25.30	3.88
p	26.16	26.34	23.32	23.68	25.85	25.59	26.04	26.04	30.47	30.19
n	144	138	30	29	37	34	53	53	24	22

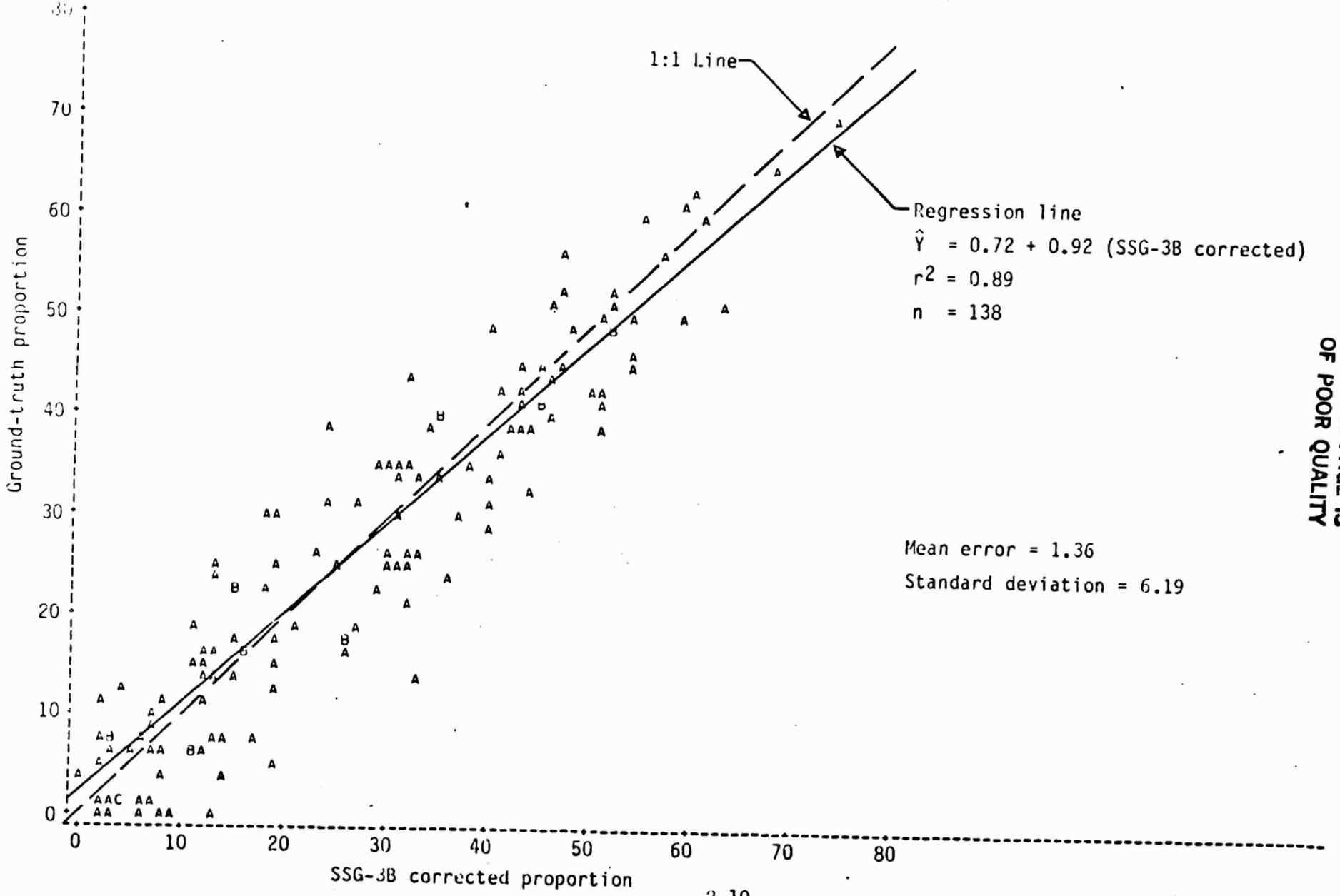
STATISTIC	LACIE PHASE II	LACIE PHASE III	LACIE TY 1978		1980 SSG
	1976	1977	U.S.	SK.	EXPLORATORY
e	-5.51	-6.10	-4.0	-2.9	-3.5
S_e	8.52	5.40	7.40	7.36	5.9
RM RME	-24.51	-17.48	-13.94	-6.8	-11.9
n	35	45	38	15	35

*NOTE: SSG-3B1 = SSG-3B CORRECTED.

SSG-3B PROPORTION ESTIMATES VERSUS GROUND-TRUTH PROPORTIONS FROM FY '81 PILOT



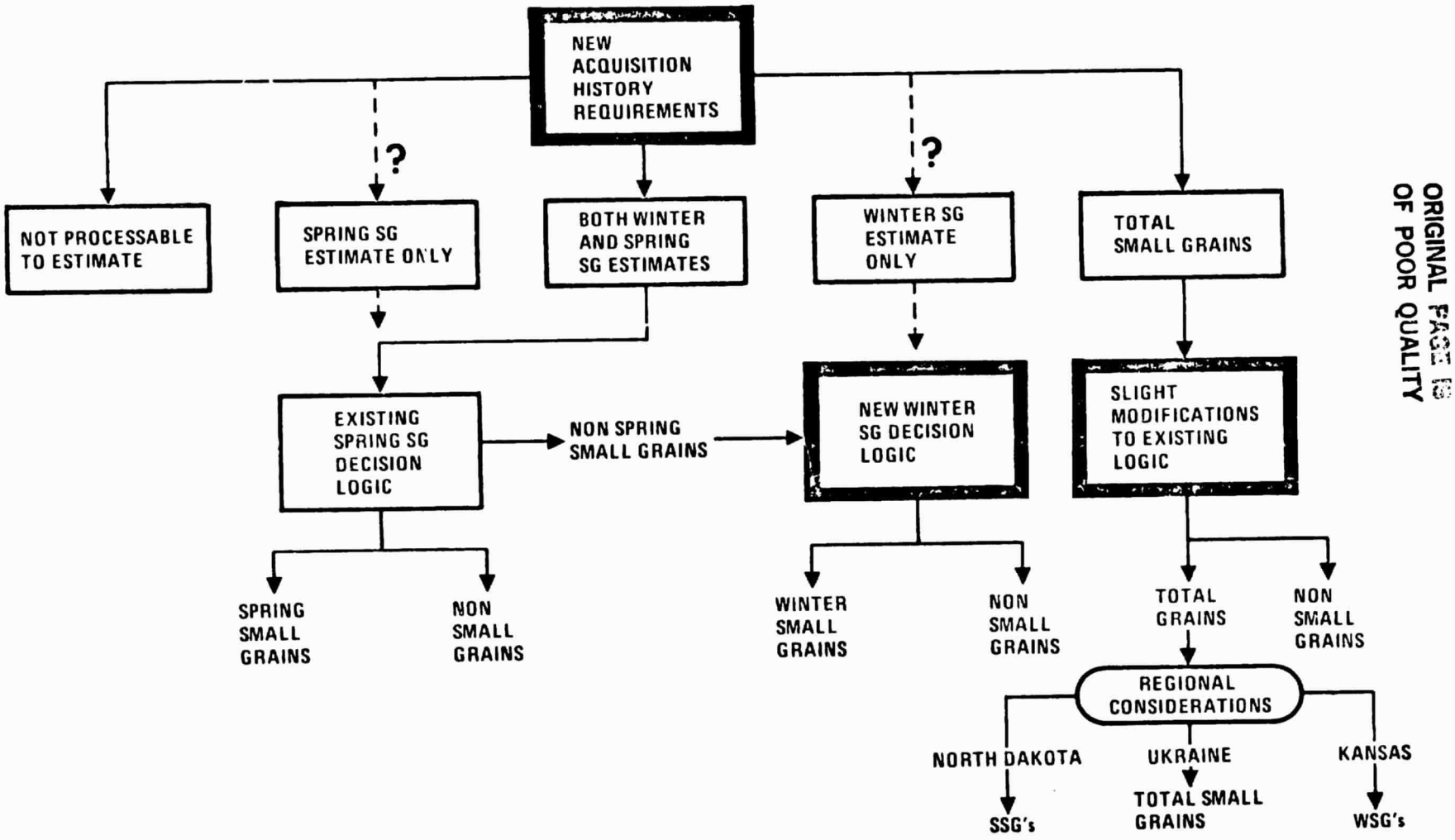
CORRECTED SSG-3B PROPORTION ESTIMATES VERSUS GROUND-TRUTH PROPORTIONS



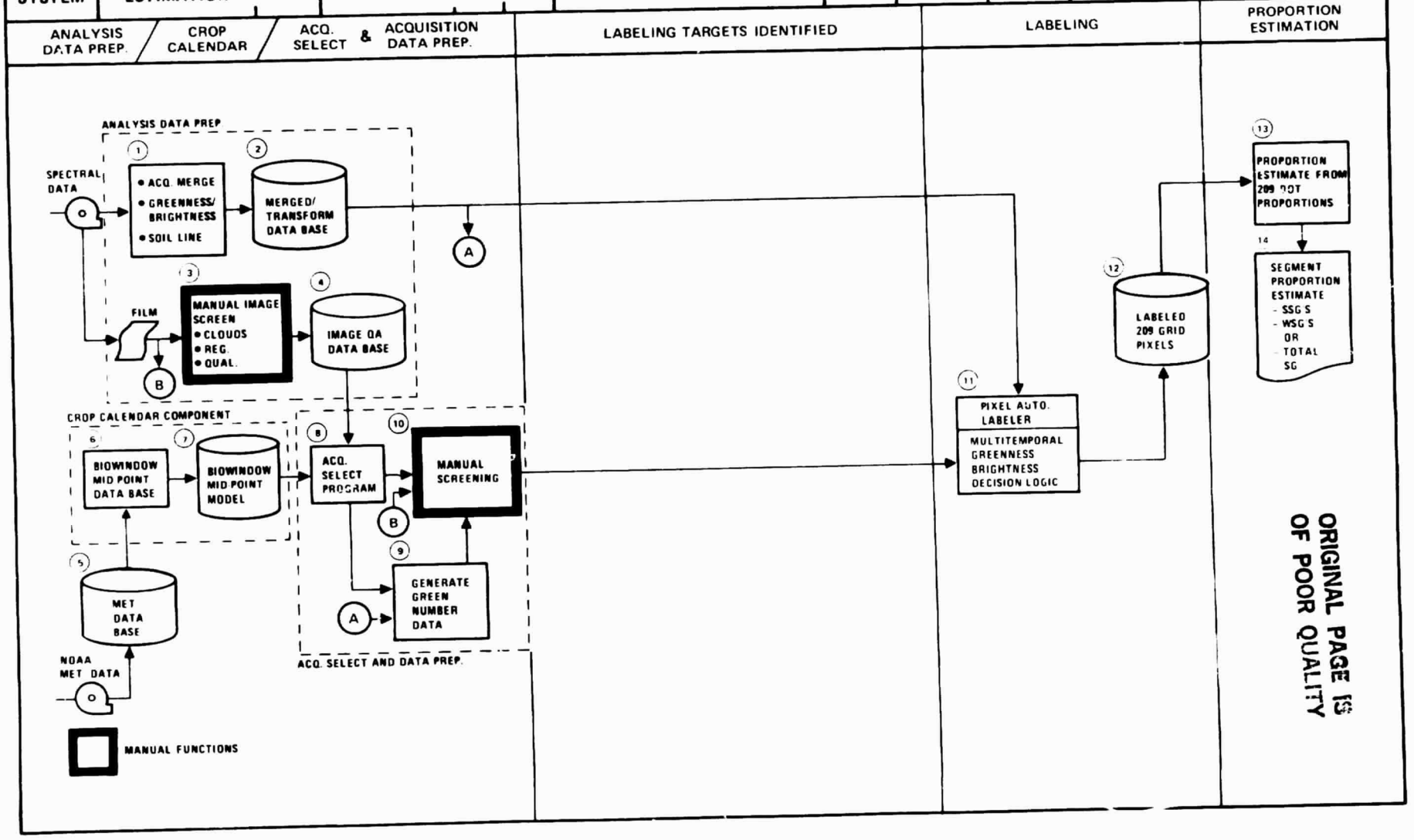
SPRING SMALL GRAINS DEVELOPMENT/RESULTS (CON'T.)

- ADVANCED SMALL GRAINS DEVELOPMENT SG-1
  - + WHILE AWAITING RESULTS FROM THE SENSITIVITY STUDIES AND THE SUBCOMPONENT RESEARCH STUDIES, THE DEVELOPMENT OF A TOTAL SMALL GRAINS PROPORTION ESTIMATION TECHNOLOGY HAS BEEN INITIATED.
    - ++ UTILIZE THE SSG-3B DESIGN AS A BASIS
    - ++ DESIGN AND IMPLEMENT A WINTER GRAINS ESTIMATOR SUBCOMPONENT
    - ++ INVESTIGATE THE UTILITY OF A BOUNDARY DOT RELOCATION TECHNIQUE DEVELOPED AND TESTED IN FY81
  - + LONG RANGE PLAN
    - ++ THIS GENERIC PROPORTION ESTIMATION TECHNOLOGY (SG-1) WILL BE INTEGRATED WITH USSR AND/OR AUSTRALIA FEATURES IDENTIFICATION STUDIES FOR THE NECESSARY ADAPTATIONS TO THE DESIGN AND IMPLEMENTATION OF FOREIGN SPECIFIC AREA ESTIMATION TECHNOLOGY DEVELOPMENT.

SG-1 FUNCTIONAL DESIGN



LEVEL	TYPE	COMP. CODE	DESIGNATOR: CROP PROC.	DESIGNATOR: NO.	DESIGNATOR: VAR.	PROCEDURE NAME	PROCEDURE CHARACTERISTICS: DATA	SAMPLE	PERIOD	REGION	TIME OF EST.	DATE
SUB-SYSTEM	AREA ESTIMATION	A	SG	1		CAESAR (SEMIAUTO.)	MSS	SEGMENT	YEARLY	U.S.	PRE-HARVEST	



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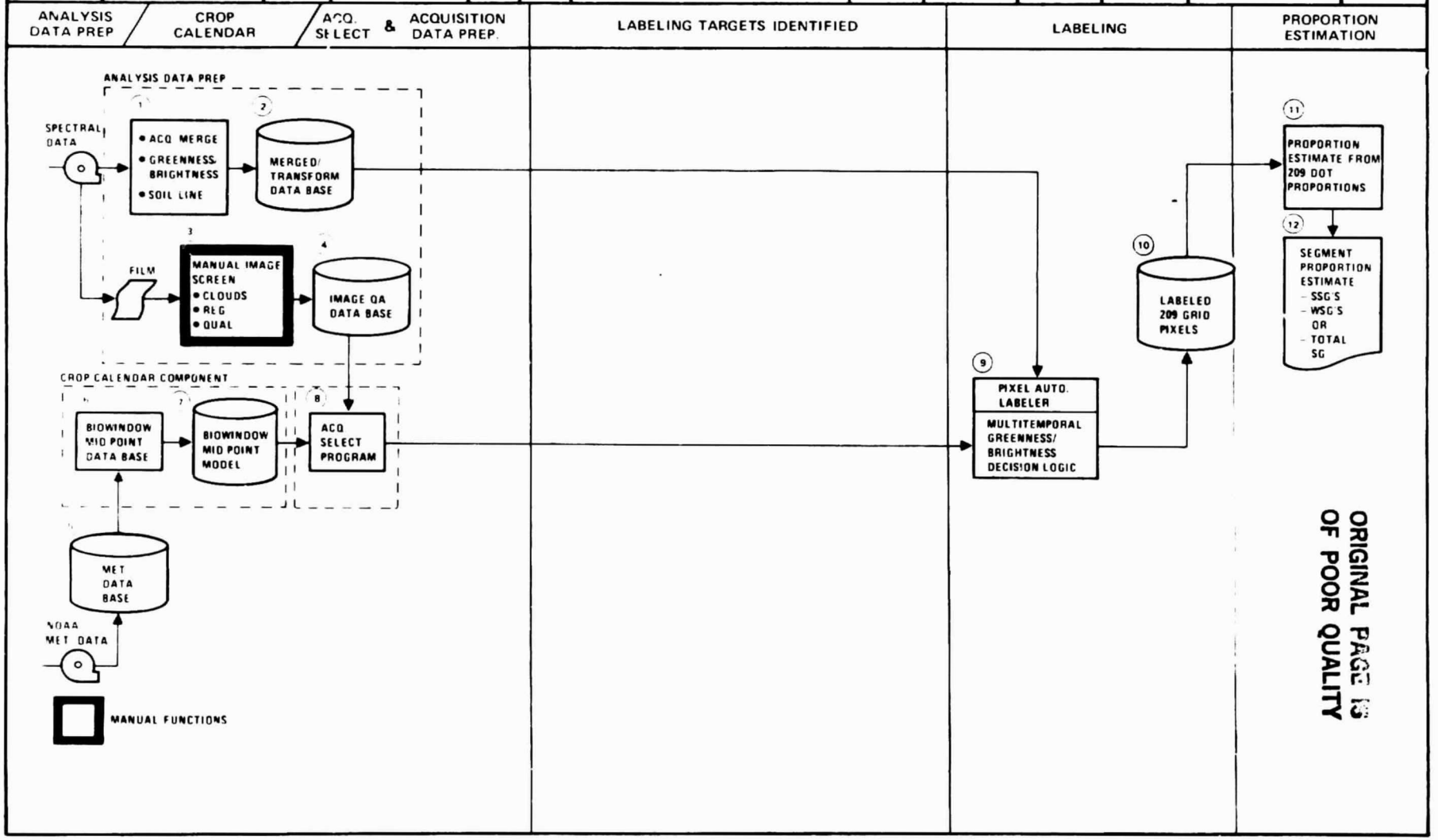
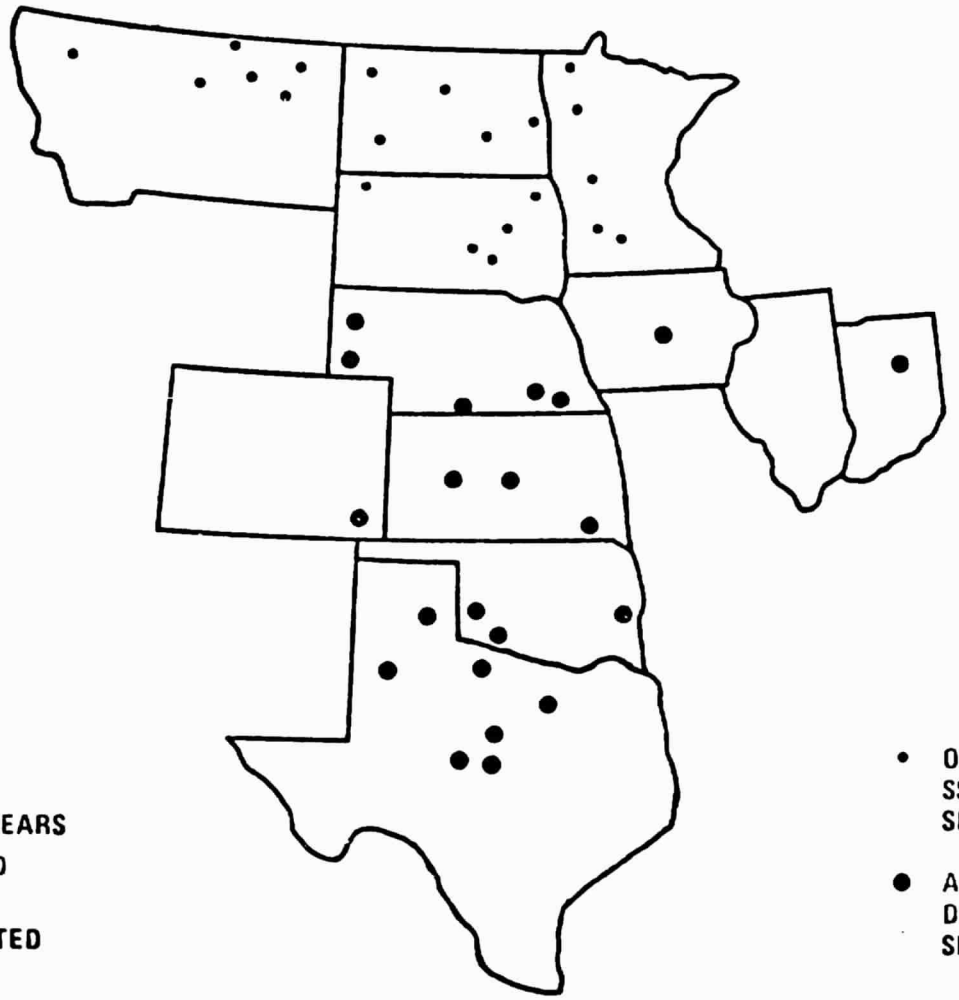
			CROP PROC.	NO.	VAR.		DATA	SAMPLE	PERIOD	REGION	TIME OF EST.	
SUB-SYSTEM	AREA ESTIMATION	A	SG	1	A	CAESAR (AUTO.)	MSS	SEGMENT -PIXEL	YEAR	U.S.	PRE-HARVEST	3/30/82



DEVELOPMENT DATA SET FOR SG-1



SCOPE

- MAJOR U.S. WHEAT REGIONS; 4 CROP YEARS
- DIGITIZED GROUND TRUTH SEGMENTS
- RANDOMLY SELECTED

- ORIGINAL SSG DEVELOPMENT SEGMENTS
- ADDITIONAL WSG DEVELOPMENT SEGMENTS

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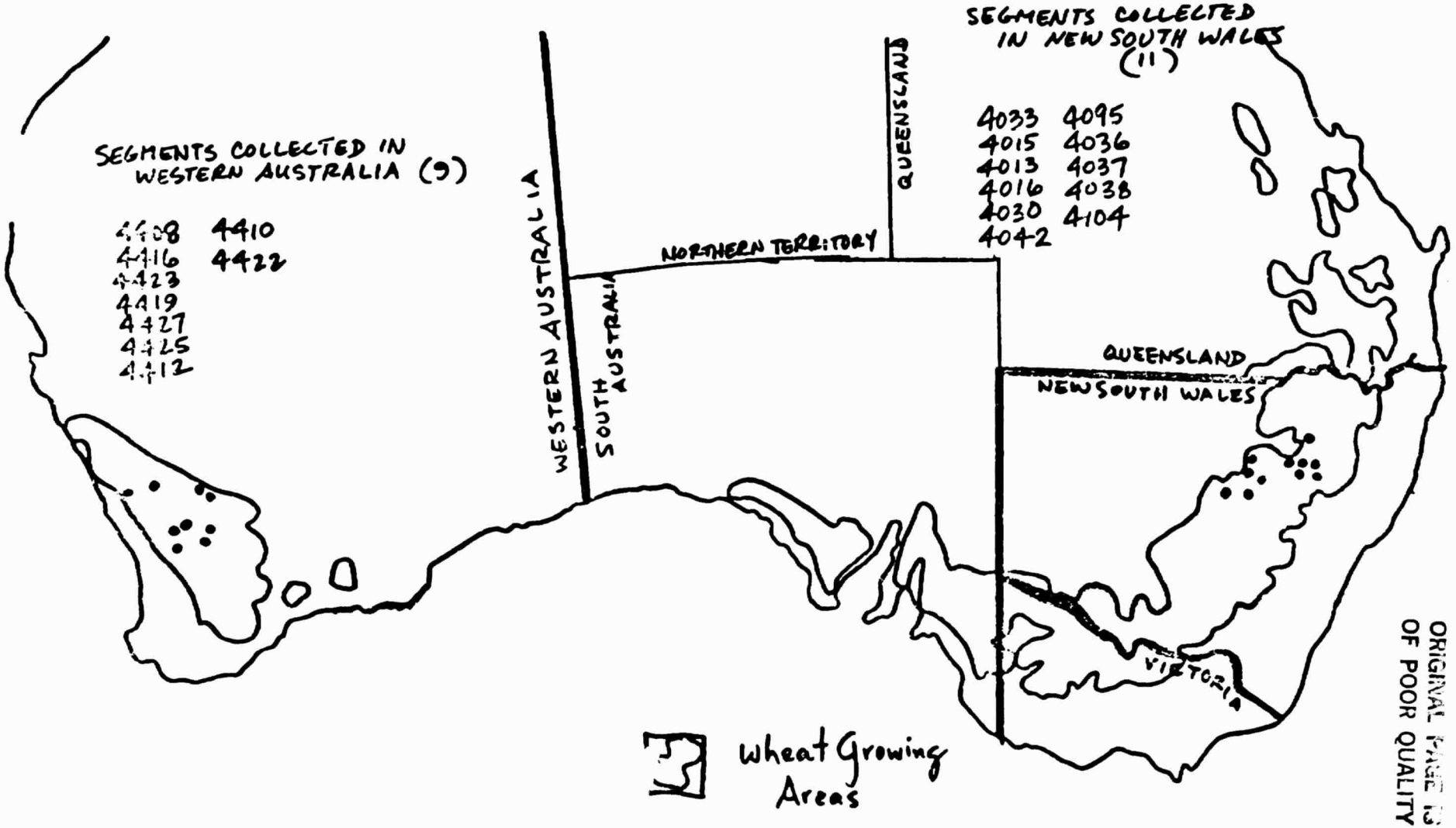
Administrative Divisions

AUSTRALIA

1981-1982 CROP YEAR

GROUND DATA COLLECTION SITES



SUMMER CROPS, CORN/SOYBEANS RESULTS

- CS-1B, SEMIAUTOMATED SUMMER CROP, CORN/SOYBEANS PROPORTION ESTIMATION TECHNOLOGY EVALUATION

  BACKGROUND:

  + CS-1 TECHNOLOGY DURING FY81 PILOT EXPERIMENT WAS INITIAL IMPLEMENTATION OF RESEARCH AND DEVELOPMENT IN CORN/SOYBEANS PROPORTION ESTIMATION TECHNOLOGY.

    ++ NEW SUBCOMPONENT MODULES

    - NORMALIZATION
    - ACQUISITION SELECTION
    - TARGET IDENTIFICATION
    - LABELING LOGIC
    - PROPORTION ESTIMATION

  + THE PLANNED EVALUATIONS IN THE PILOT EXPERIMENT ALLOWED FOR THE IDENTIFICATION AND QUANTIFICATION OF SUBCOMPONENT CONTRIBUTION TO THE PROPORTION ESTIMATION ERROR.

  + THESE RESULTS GUIDED THE DESIGN AND IMPLEMENTATION OF AN IMPROVED TECHNOLOGY (CS-1A).

COMPARISON OF C/S AREA ESTIMATION PROCEDURES

PROCEDURE NAME	CS-1	CS-1A	MC-2	CS-4	CS-2A	CS-5
DEVELOPER	ERIM/UCB	ERIM/UCB/LEMSCO	LEMSCO	JSC/LEMSCO	JSC/LEMSCO/ERIM	ERIM/UCB
CROP CALENDAR	HISTORIC	HISTORIC	MODEL	MODEL	HISTORIC	OPTIONAL
PREPROCESSING	EXTERNAL EFFECTS	EXTERNAL EFFECTS	GREY LEVEL	SUN ANGLE	OPTIONAL	EXTERNAL EFFECTS
FEATURE EXTRACTION	TASSELED CAP, GRABS	TASSELED CAP, GRABS	SPATIAL COLOR SEQUENCE	PROFILE PARAMS α,β,σ	TASSELED CAP GRABS	TASSELED CAP
LABELING TARGET	QUASI-FIELDS	QUASI-FIELDS	BIN	SUPER PURE DOT	RELOCATED DOT	OPTIONAL
LABELING METHOD	ANALYST DECISION TREE	ANALYST/MACHINE DECISION TREE	AUTOMATIC HISTORICAL COLOR SEQUENCE	ANALYST/MACHINE PROFILE FEATURE THRESHOLDS	AUTOMATIC DECISION TREE	SIGNATURE PROFILE MATCHING
ESTIMATION METHOD	STRATIFIED AREA ESTIMATE (S.A.E.)	BIAS CORRECTED S.A.E.	BIAS CORRECTED AGGREGATION	LINEAR DECISION RULE	RELATIVE COUNT	IN DEVELOPMENT
EFFICIENCY	MANUAL	SEMI-AUTOMATIC	AUTOMATIC	SEMI-AUTOMATIC	SEMI-AUTOMATIC	AUTOMATIC
TIMELINESS	POST TASSELING	POST TASSELING	PRE-SEED	POST TASSELING	POST TASSELING	THROUGH SEASON
AREA OF APPLICATION	U.S. CORN BELT	U.S. CORN BELT	U.S. CORN BELT	U.S. CORN BELT	U.S. CORN BELT	ARGENTINA FSRs
CROPS	C,S	C,S	C,S	C,S	C,S	C,S

SPECIFIC OBJECTIVES OF THE FY81 CORN AND SOYBEANS EXPERIMENT *

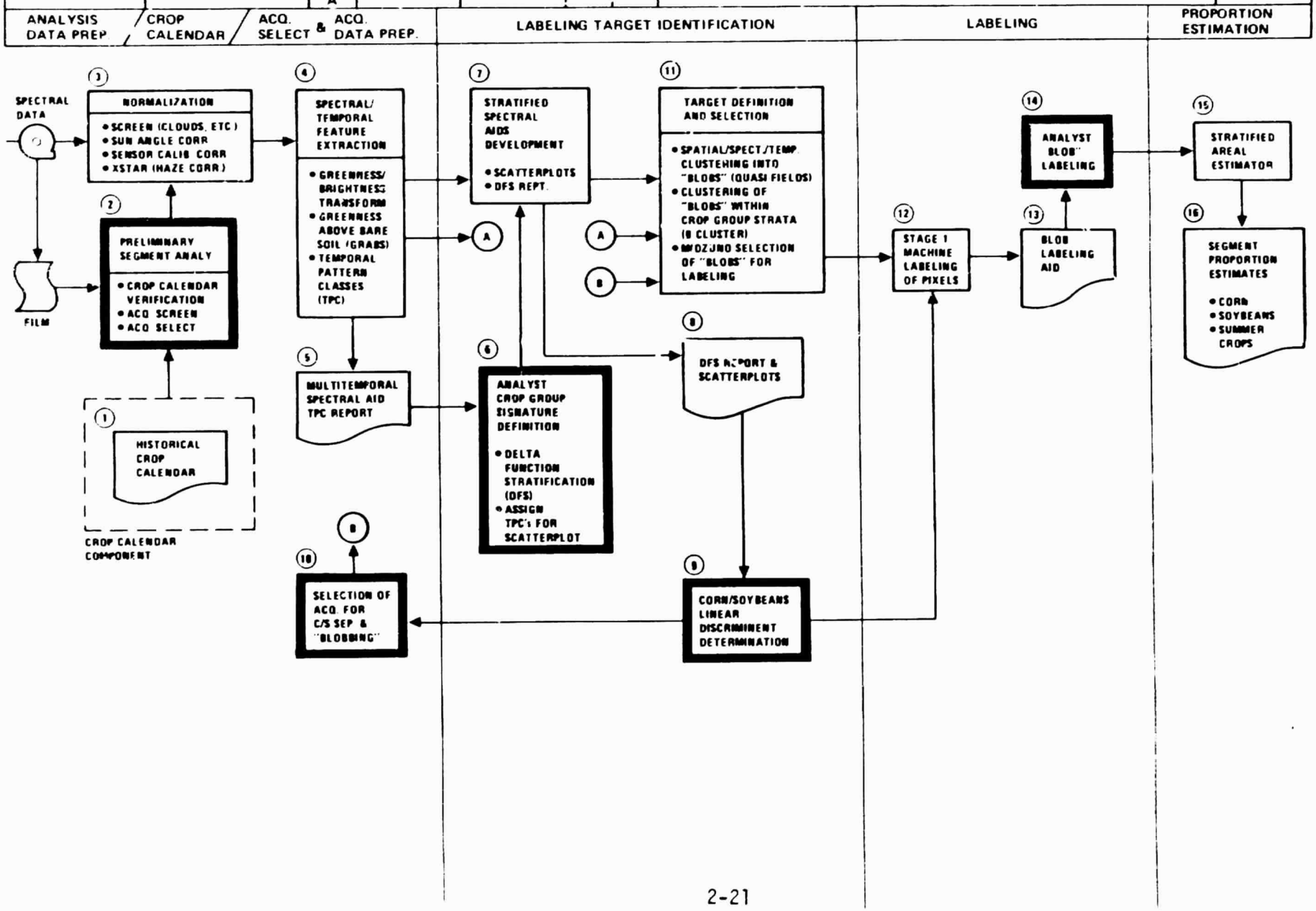
- ADAPT A CORN AND SOYBEAN PRODUCTION ESTIMATION TECHNOLOGY TO A NEW CROP REGION USING EXISTING AREA ESTIMATION SUBCOMPONENTS - E.G., LABELING AND PROPORTION ESTIMATION - AND A CONSORTIUM OF RESEARCH AND DEVELOPMENT INSTITUTIONS. IMPLEMENT THIS TECHNOLOGY, ADDRESSING THE TECHNICAL NEEDS IDENTIFIED IN THE FY80 EXPLORATORY, AS A BASELINE FOR THE DEVELOPMENT OF A TECHNOLOGY FOR FOREIGN APPLICATION.

- DEVELOP AND IMPLEMENT AN EXPERIMENTAL METHODOLOGY WHICH WILL TEST THIS TECHNOLOGY AND PROVIDE EVALUATION RESULTS TO BE INCORPORATED INTO FURTHER DEVELOPMENT.

- EVALUATE THE PERFORMANCE OF THE BASELINE TECHNOLOGY IN A CONTROLLED EXPERIMENTAL ENVIRONMENT TO IDENTIFY AND QUANTIFY THE SUBCOMPONENTS THAT CONTRIBUTE THE SIGNIFICANT PROPORTION OF ERROR TO THE SEGMENT PROPORTION ESTIMATE SO AS TO FOCUS FURTHER DEVELOPMENT.

* FROM SEMI-ANNUAL PROJECT MANAGEMENT REPORT, NOV. 1981

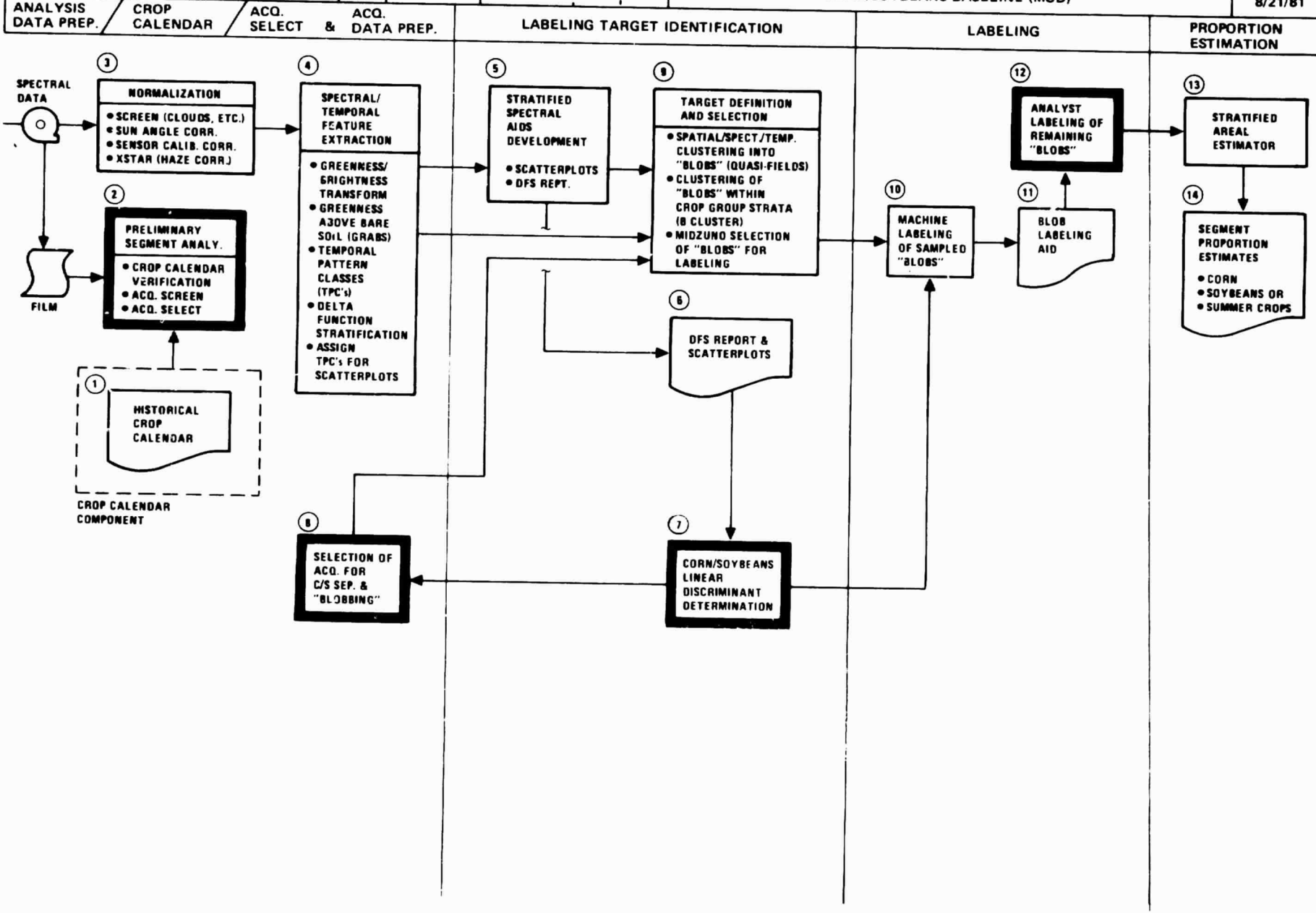
LEVEL	TYPE		REGION	CROP PROC.	NO.	VAR.	PROCEDURE NAME	DATE
SUBSYSTEM	AREA ESTIMATION	CODE A	U.S.	C/S	1		CORN/SOYBEANS BASELINE	8/21/81



IDENTIFIED SUBCOMPONENT ERROR SOURCES IN CS-1 TECHNOLOGY AND PROPOSED MODIFICATIONS

WEAKNESS IN C/S-1	MODIFICATION FOR C/S-1A
LABELING PERFORMANCE	
1. INCONSISTENT LABELING OF PURE TARGETS	1. MACHINE LABELS "CLASSIC" TARGETS, PARTIALLY LABELS REMAINING TARGETS.
2. MISDETECTION OF CROPS WITH TWO VEGETATION PHASES.	2. LABELING LOGIC REFINED, EXAMPLES GIVEN.
3. FEW MIXED TARGETS DETECTED	3. MACHINE IDENTIFIES POTENTIALLY MIXED TARGETS
4. POOR LABELING PERFORMANCE ON MIXED TARGETS	4. LABEL SELECTED PIXELS FROM MIXED TARGET, NOT TARGET MEAN.
5. STRATIFICATION ASSIGNMENT TEDIOUS AND ERROR PRONE	5. AUTOMATED STRATIFICATION
6. C/S DISCRIMINANT	7. MULTIDATE SCATTERPLOT AND DEFAULT LINE.
MACHINE PERFORMANCE	
1. TARGET DEFINITION	1. REDUCE NUMBER OF MIXED TARGETS A) IMPROVED ACQUISITION SELECTION B) MODIFIED TARGET ALGORITHM
2. BIASED TREATMENT OF UNSAMPLED STRATUM	2. ASSIGN LITTLE TARGETS TO CLUSTERS.

LEVEL	TYPE		REGION	CROP PROC.	NO.	VAR.	PROCEDURE NAME	DATE
SUBSYSTEM	AREA ESTIMATION	CODE A	U.S.	C/S	1	A	CORN/SOYBEANS BASELINE (MOD)	8/21/81



PAIRED SEGMENT COMPARISON OF C/S-1 AND C/S-1A POOLED YEARS

CORN

	C/S-1	C/S-1A
$\bar{E}$	6.83	1.38
S_E	2.5	5.6
MAE	6.83	5.2
RME	23.0	4.6
$\bar{P}$	29.7	29.7
N	5	5

SOYBEAN

	C/S-1	C/S-1A
$\bar{E}$	-3.8	-2.69
S_E	1.2	2.5
MAE	3.8	2.8
RME	-15.8	-11.2
$\bar{P}$	24.1	24.1
N	5	5

SUMMER

	C/S-1	C/S-1A
$\bar{E}$	3.02	-1.30
S_E	2.2	3.8
MAE	3.02	2.8
RME	5.6	-2.4
$\bar{P}$	53.8	53.8
N	5	5

SEGMENTS USED - 1973 IOWA

144 - 2 PROCESSING IN C/S-1

145

804

856

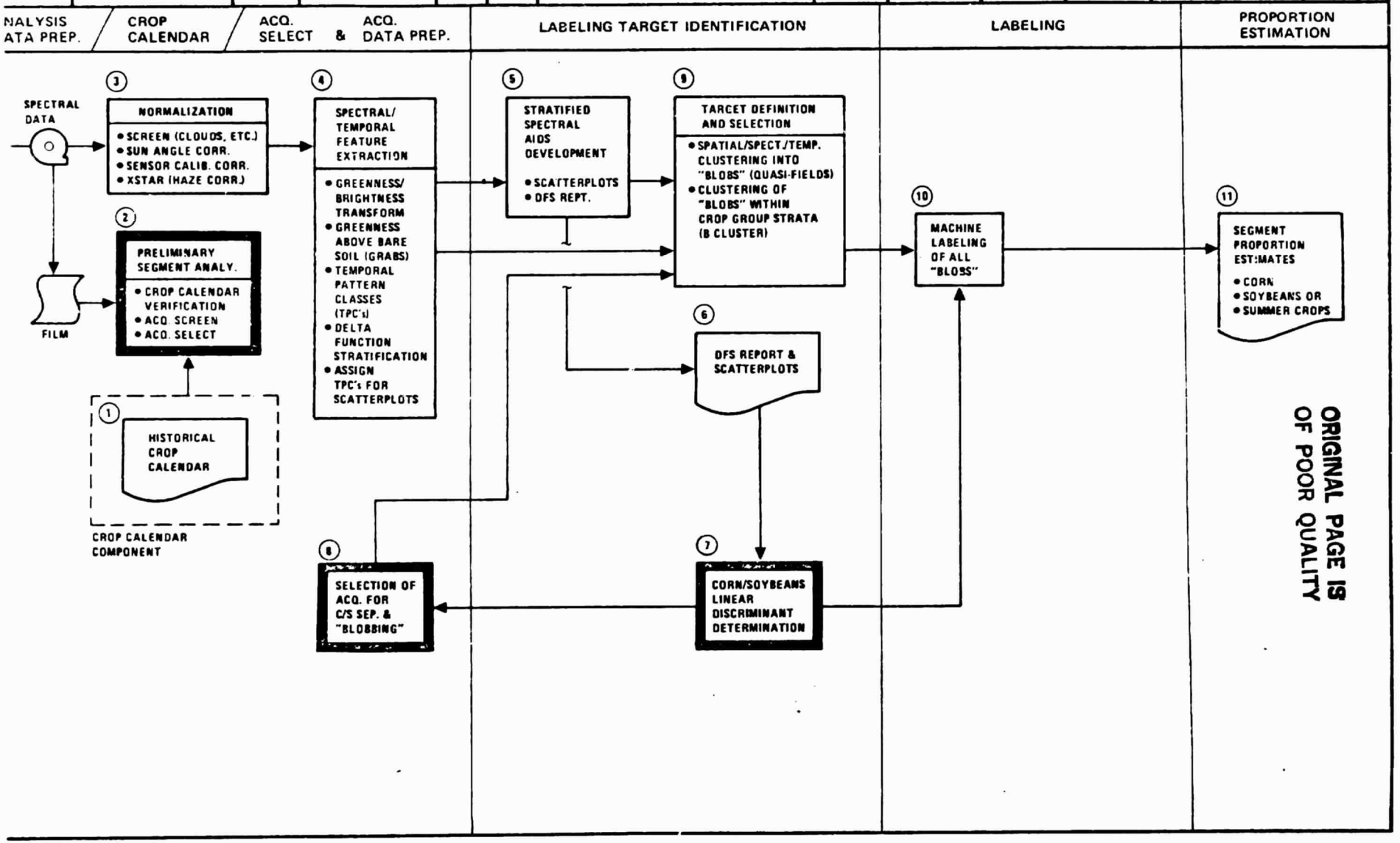
SUMMER CROPS, CORN/SOYBEANS CONCLUSIONS FROM CS1A TEST

+ TEST RESULTS FROM THE C/S-1A TECHNOLOGY WERE SUFFICIENT TO WARRANT SUBMISSION TO EXTENDED SUBCOMPONENT TESTING USING AN INDEPENDENT DATA SET (69 SEGMENTS IN IOWA, 1980 CROP YEAR).

+ THE DESIGN AND IMPLEMENTATION OF AUTOMATED SUBCOMPONENTS OF THE C/S-1A TECHNOLOGY PROCEEDED FASTER THAN ANTICIPATED. ALSO, DEVELOPMENTAL TEST RESULTS WERE VERY ENCOURAGING.

+ THE DECISION WAS MADE TO CONFIGURE AND INCORPORATE THE NEW AUTOMATED TECHNOLOGY C/S-1B INTO THE TEST. (MANUAL SUBCOMPONENTS OF C/S-1B UTILIZED PROCESSING RESULTS FROM THOSE IDENTICAL SUBCOMPONENTS OF THE C/S-1A).

EVEL	TYPE	COMP. CODE	DESIGNATOR			PROCEDURE NAME	PROCEDURE CHARACTERISTICS					DATE
			CROP PROC.	NO.	VAR.		DATA	SAMPLE	PERIOD	REGION	TIME OF EST.	
UB-YSTEM	AREA ESTIMATION	A	C/S	1	B	CORN/SOYBEANS BASELINE (MOD 2)	MSS	SEGMENT	YEARLY	U.S. CORN BELT	PRE-HARVEST	4/7/82



C/S-1B TEST RESULTS

1978-79 C/S SEGMENT IN IOWA, INDIANA AND ILLINOIS

DEVELOPMENT TESTING			
	CORN	SOYBEAN	SUMMER
$\bar{E}$	1.59	-0.30	1.29
S_E	9.39	7.68	9.77
R.M.E.	4.19	-1.18	2.02
M.A.E.	7.57	5.43	7.32
$\bar{P}$	37.91	25.35	36.75
N	14	14	14

SHAKEDOWN TEST			
	CORN	SOYBEAN	SUMMER
$\bar{E}$	3.36	-3.37	-0.01
S_E	5.70	3.69	6.39
R.M.E.	10.18	-12.26	-0.01
M.A.E.	5.05	3.94	4.87
$\bar{P}$	33.02	27.48	60.50
N	10	10	10

IOWA

	Corn	Soybeans	Summer Crops
$\bar{e}$	4.41	1.82	6.32
S_e	5.96	3.32	8.74
R.M.E.	10.98	9.97	10.81
M.A.E.	5.93	2.75	7.68
p	40.18	18.24	58.42
n	18	18	22

PROCEDURES EFFICIENCY
PER SEGMENT

	C/S-1	C/S-1B	
MANUAL FUNCTIONS			
DATA PREPARATION	1.25 HRS	1.25 (TECHNICIAN)	Time Factors
PROCEDURE EXECUTION	25.17 HRS	1.75 (ANALYST)	(Acquisition Selection Discriminant Definition)
TOTAL	26.42 HRS	3.0 HRS	
COMPUTER FUNCTIONS			
CPU	26 MIN	.5 MIN	
CONNECT	97 MIN	12. MIN	

PROCESSABILITY

1980 IOWA

	C/S-1A	C/S-1B
SEGMENTS ALLOCATED	69	69
SEGMENTS PROCESSED TO CROP GROUP	49 (71%)	49 (71%)
SEGMENTS PROCESSED TO CROP TYPE	44 (64%)	44 (64%)

SUMMER CROPS, CORN/SOYBEANS CONCLUSIONS FROM CS1B TEST

- C/S-1B DEVELOPMENT HIGHLY SUCCESSFUL
  - + MAJOR SOURCES OF ERROR IN C/S-1 TECHNOLOGY IDENTIFIED AND QUANTIFIED.
  - + MODIFICATIONS OF THE PROBLEM SUBCOMPONENTS SUCCESSFUL AND TIMELY.
  - + DUE TO OBJECTIVE NATURE OF THE TECHNOLOGY, THE DESIGN AND IMPLEMENTATION OF AUTOMATED COMPONENTS WAS STRAIGHTFORWARD.
  - + THE PRELIMINARY ASSESSMENTS OF THE TEST RESULTS INDICATE THAT THE SUBSTANTIAL IMPROVEMENTS GAINED IN THE AUTOMATION OF THE CS1 TECHNOLOGY SHOULD LEAD TO TECHNOLOGY THAT SATISFIES ALL THE APPLICABLE PERFORMANCE CRITERIA.

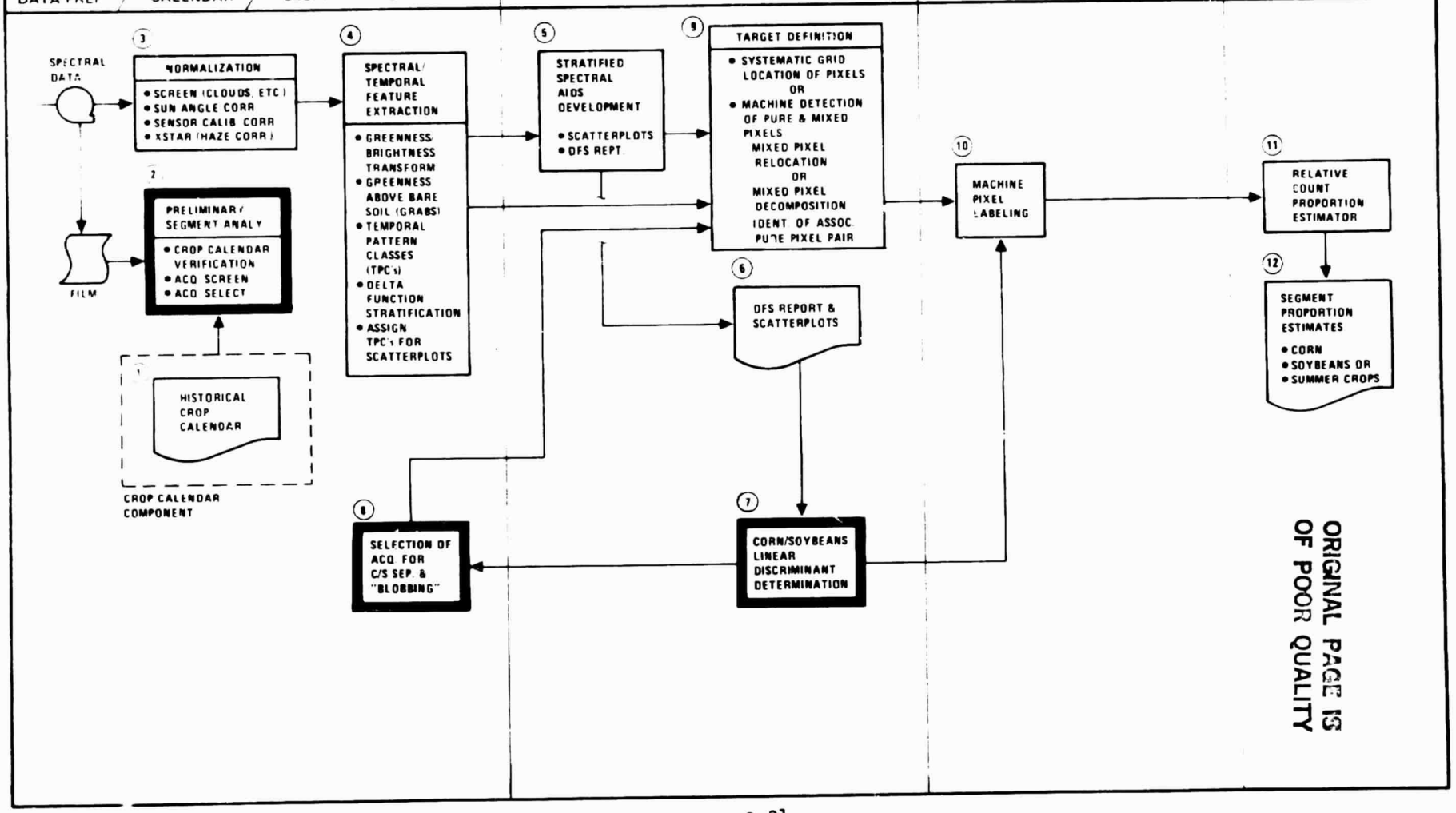
C/S-1 DEVELOPMENT FUTURE ACTIVITIES

- NEXT PHASE OF DEVELOPMENT IN THE CS-1 FAMILY IS TO BEGIN AN ATTACK TO UNDERSTAND SIGNIFICANCE AND POSSIBLE SOLUTION TO BOUNDARY/MIXED TARGET. A VERSION (CS-1C) HAS BEEN DESIGNED WITH AN APPROACH TO THIS PROBLEM AREA.

- THE LONG RANGE PLAN HAD BEEN TO CONTINUE THE, THUS FAR, SUCCESSFUL RESEARCH, DESIGN, TEST, EVALUATE, RESEARCH, ... DEVELOPMENTAL CYCLE. RESEARCH HAS BEEN ONGOING IN GAINING UNDERSTANDING OF CORN/SOYBEANS SIGNATURES AND CHARACTERISTICS UNDER A VARIETY OF CONDITIONS. CURRENT FINDINGS GIVE INDICATIONS THAT SOME OF THE VARIATION CAN BE DETECTED BY LANDSAT DERIVED PARAMETERS.

- AS RESOURCES ALLOW, THE DEVELOPMENT OF AREA ESTIMATION TECHNOLOGY IN CORN/SOYBEANS FOR DIRECT FOREIGN UTILIZATION WILL TAKE ADVANTAGE OF THE RESULTS FROM THE TESTS AND DEVELOPMENT CAPABILITIES ESTABLISH OVER THE PAST TWO YEARS.

LEVEL	TYPE	COMP. CODE	DESIGNATOR			PROCEDURE NAME	PROCEDURE CHARACTERISTICS					DATE
			CROP PROC.	NO.	VAR.		DATA	SAMPLE	PERIOD	REGION	TIME OF EST.	
SUB-SYSTEM	AREA ESTIMATION	A	C/S	1	C	CORN/SOYBEANS BASELINE (MOD-3)	MSS	SEGMENT	YEARLY	U.S.	PRE-HARVEST	3/30/82



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CROP SIGNATURE CHARACTERIZATION

FIELD REFLECTANCE DATA ANALYSES

Accomplishments

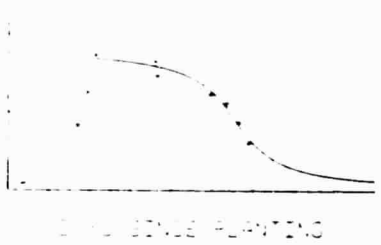
- Effects of Experimental Treatments on Green and Bright Reflectance Profiles Were Determined for Corn and Soybeans. Typical Variations in Factors Such as Nitrogen Availability, Planting Date, and Variety Can Cause Significant Changes in Corn and Soybean Spectral Development Patterns.

- Association of Green Reflectance Profile Features With Stages of Development Was Determined for Corn and Soybeans. Corn Peaks Well Before Tassel Emergence and Peak LAI, While the Soybean Profile Peak is Associated Not With Development Stage But With Canopy Closure.

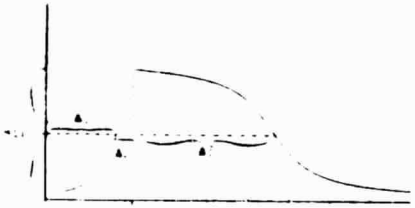
- Separability of Corn and Soybeans in This Reflectance Data Set was Determined. Based on Peak Green Reflectance Value and Rate of Green Decline After Peak (Plateau in Corn), the Two Crops are Completely Separable. However, Variations in Field Conditions Tend to Act on These Same Profile Features, and Could Therefore Influence Separability.

CULTURAL AND ENVIRONMENTAL EFFECTS ON CORN AND SOYBEAN PROFILES

(1) Fit Curve to Reflectance Data



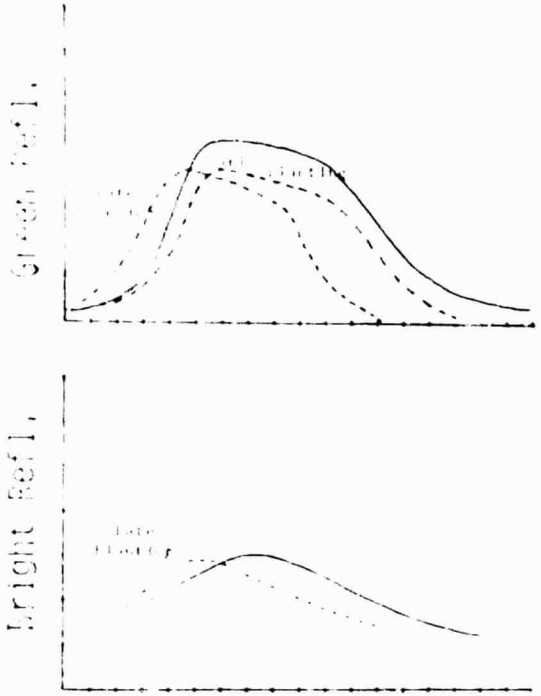
(2) Extract Profile Features



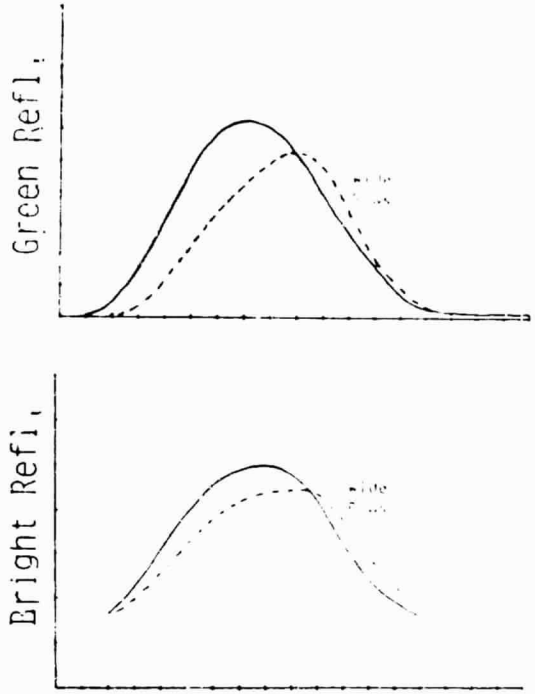
(3) Compare Treatment Effects

- ANOVA
- Qualitative

Corn - Planting Date



Soybeans - Row Spacing



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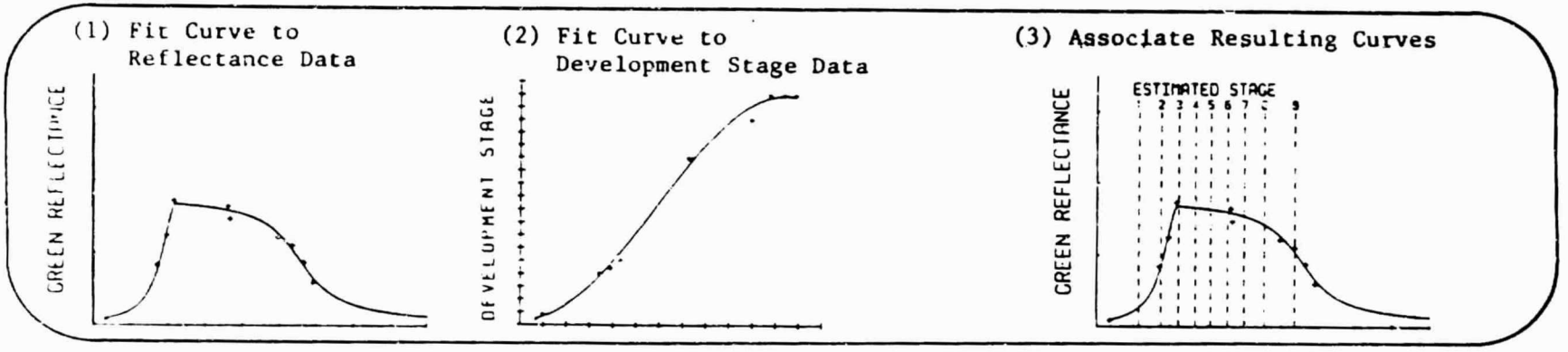
ASSOCIATION OF SPECTRAL AND DEVELOPMENTAL EVENTS



- Peak Green Refl. at Stage 2.5 to 3.0
  - Two weeks prior to tassel emergence
  - Three weeks prior to expected peak LAI
- "Early" Peak Probably Related to
  - Vertical leaf distribution/shadowing by stem
  - Leaf angular orientation
  - Shadowing by tassels

Soybeans

- Peak Green Refl. Occurs at Wide Range of Vegetative and Reproductive Stages
- Strong Association Between Profile Peak and Maximum Canopy Closure
- Lack of Development Stage Association Probably Due to
  - Indeterminate nature of many soybean varieties
  - Density of soybean vegetative canopy

SUMMARY

- SIGNIFICANT PROGRESS HAS BEEN MADE IN AUTOMATING THE BASELINE SUMMER CROP/CORN/SOYBEANS PROPORTION ESTIMATION TECHNOLOGY.

- EARLY IDENTIFICATION AND QUANTIFICATION OF MAJOR SUBCOMPONENT ERROR SOURCES OF THE BASELINE AUTOMATED SPRING SMALL GRAINS TECHNOLOGY HAS GUIDED THE DEVELOPMENT OF IMPROVEMENTS AND EXTENSIONS FOR FOREIGN ADAPTATION.

- THE EXERCISE OF THE TECHNIQUES DEVELOPMENT SYSTEM CONCEPT HAS PROVEN TO BE AN EFFICIENT MEANS FOR ADVANCING THE TECHNOLOGY. THIS SYSTEM APPROACH SHOULD PROVIDE SIGNIFICANT CAPABILITY FOR FUTURE RESEARCH AND DEVELOPMENT ACTIVITIES.

NEW ESTIMATION APPROACHES
AND
FUTURE DATA ACQUISITION SYSTEMS
REQUIREMENTS DEFINITION

M. C. TRICHEL
APRIL 19, 1982

INTRODUCTION

- IN MID-1981
  - AVAILABILITY OF RESEARCH DATA BASES
  - EXPERIENCE WITH SIGNATURE STABILIZING TRANSFORMS
  - DISCUSSIONS WITH FCCAD

  LED TO INITIATION OF HIGH-RISK AREA ESTIMATION APPROACHES ADDRESSING FOLLOWING:
  - EARLY SEASON ESTIMATION
  - REQUIREMENTS FOR REGISTERING, STORING LANDSAT DATA
  - TIMELINESS, FREQUENCY OF COVERAGE OF LANDSAT DATA
    + MOTIVATES FCCAD USE OF ENVIRONMENTAL SATELLITE DATA
  - ANALYSIS COST
  - FOREIGN ADAPTATION

- THREE OF THE FIVE SUCH ACTIVITIES ARE TO BE DISCUSSED HERE.
  - SMALL, HIGHLY SIGNIFICANT FRACTION OF ITD
    + EARLY SEASON APPROACH
    + PROFILE CHANGE ESTIMATOR
    + SEGMENT-BASED CHANGE ESTIMATION
  - ACTIVITIES PRESAGE FUTURE SYSTEMS DEFINITION ACTIVITY

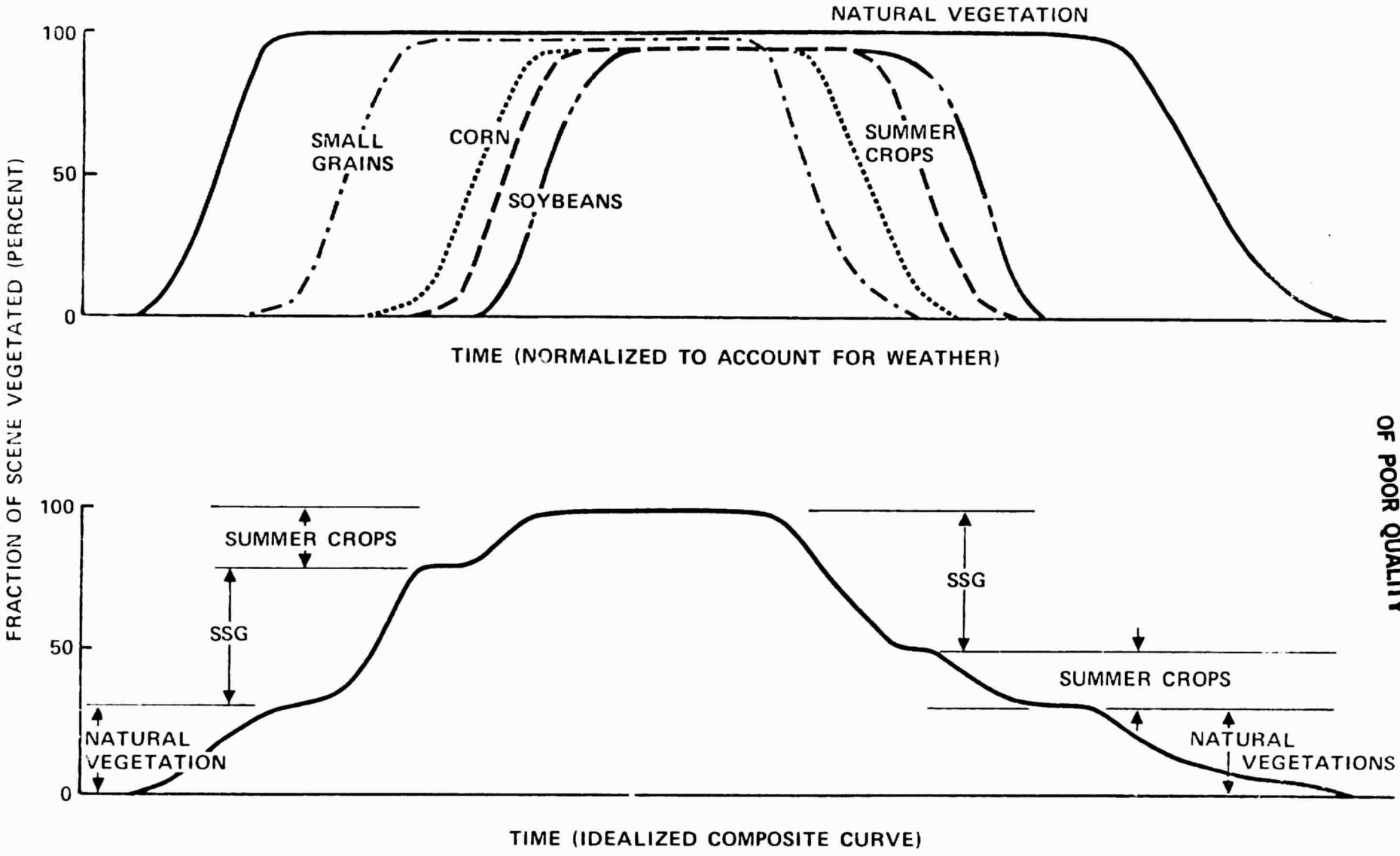
DEVELOPMENT OF EARLY SEASON APPROACH

BACKGROUND FOR EARLY SEASON APPROACH

- IN 1978, ACCOMPLISHED GOOD EARLY SEASON ESTIMATES FOR WINTER SMALL GRAINS IN THE U.S. SOUTHERN GREAT PLAINS AND THE USSR.
  - NOT SUCCESSFUL IN NORTHERN GREAT PLAINS
  - ANALYST-INTENSIVE
- ATTEMPT TO PRODUCE GOOD EARLY SEASON SPRING SMALL GRAINS ESTIMATES IN 1978 COMPLETELY UNSUCCESSFUL
  - INADEQUATE LANDSAT DATA ACQUISITION A KEY PROBLEM
- ONLY RECENTLY (MID-1981) HAVE OBTAINED SOME SUCCESS IN EARLY SEASON SUMMER CROP ESTIMATES.
- THE PRESENT APPROACH IS BASED ON
  - TECHNICAL INPUTS FROM ERAD AND FCCAD
  - PROPORTION ESTIMATION RESEARCH FROM EARLY LACIE
    - + HARTLEY, FEIVESON, ZIEGLER, OTHERS
    - + PROMISING PRELIMINARY RESULTS NOT PREVIOUSLY PURSUED
- CURRENT RESULTS BETTER THAN STATE-OF-DEVELOPMENT WARRANTS

- BASIS
  - RELATIONSHIP BETWEEN
    - + VEGETATED AREA AT CERTAIN TIMES IN GROWING SEASON, AND
    - + AREAS OF SPECIFIC CROPS
  - RELATIONSHIP EXPLOITED VIA LINEAR MODEL
- EXPECTED ADVANTAGES
  - REQUIRES FEWER LANDSAT DATA ACQUISITIONS
  - DOES NOT REQUIRE PRECISE LANDSAT REGISTRATION
  - ALLOWS USE OF ROBUST UNBIASED ESTIMATORS
  - EXTENDABLE TO THROUGH-THE-SEASON ESTIMATION
  - POTENTIALLY ALLOWS IMPROVED FREQUENCY OF INFORMATION VIA ENVIRONMENTAL SATELLITES
    - + LANDSAT WOULD STILL BE REQUIRED

BASIS FOR EARLY SEASON APPROACH



- LINEAR MODEL

  THE OBSERVED AVERAGE SPECTRAL RESPONSE OF A SCENE MAY BE ESTIMATED AS A LINEAR COMBINATION OF THE MAJOR ELEMENTS IN THE SCENE.

$$B_I = \sum A_{IJ} X_J$$

  SUBJECT TO

$$\sum X_J = 1$$

$$X_J \geq 0$$

  WHERE B_I -- THE FRACTIONAL EMERGENCE FOR THE SCENE FOR ACQUISITION DATE I.

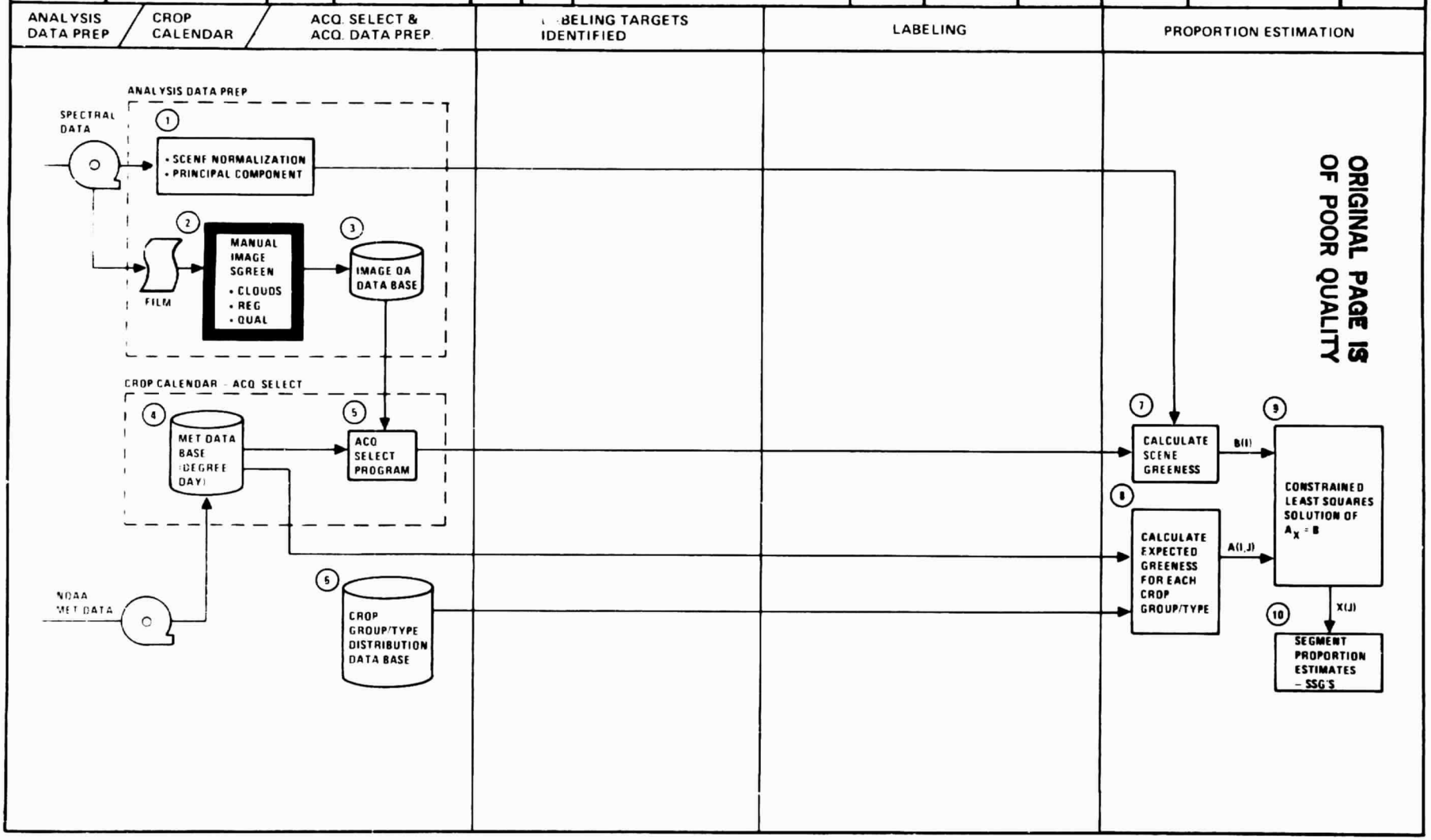
  A_{IJ} -- THE EXPECTED FRACTIONAL EMERGENCE FOR CROP J ON ACQUISITION DATE I.

  X_J -- THE PROPOPTION OF CROP J

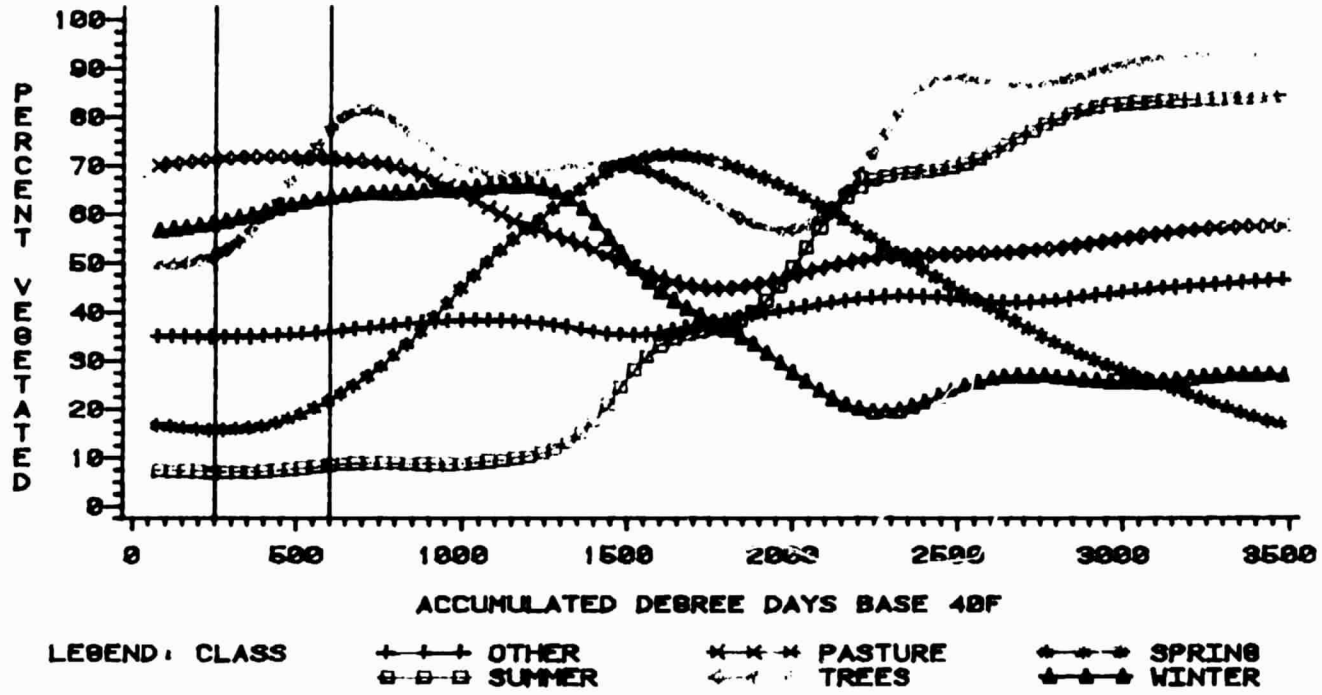
- THE X_J ARE FOUND BY A CONSTRAINED LEAST SQUARES TECHNIQUE

- CURRENT APPROACH
  - UNITEMPORAL SOLUTIONS OBTAINED AS INDICATED ON PREVIOUS PAGE
  - MULTITEMPORAL SOLUTIONS ARE AVERAGES OF UNITEMPORAL SOLUTIONS
- VARIATIONS UNDER CONSIDERATION
  - PERFORM MULTITEMPORAL SOLUTIONS AT STRATUM LEVEL
    - \+ GROUPS OF SEGMENTS
  - DEVELOP MORE APPROPRIATE MULTITEMPORAL FORMULATION
    - \+ MATRIX SOMETIMES ILL-CONDITIONED
  - USE ENVIRONMENTAL SATELLITES TO IMPROVE ESTIMATION OF TEMPORAL CURVE, FREQUENCY OF OBSERVATION
    - \+ LANDSAT STILL NEEDED

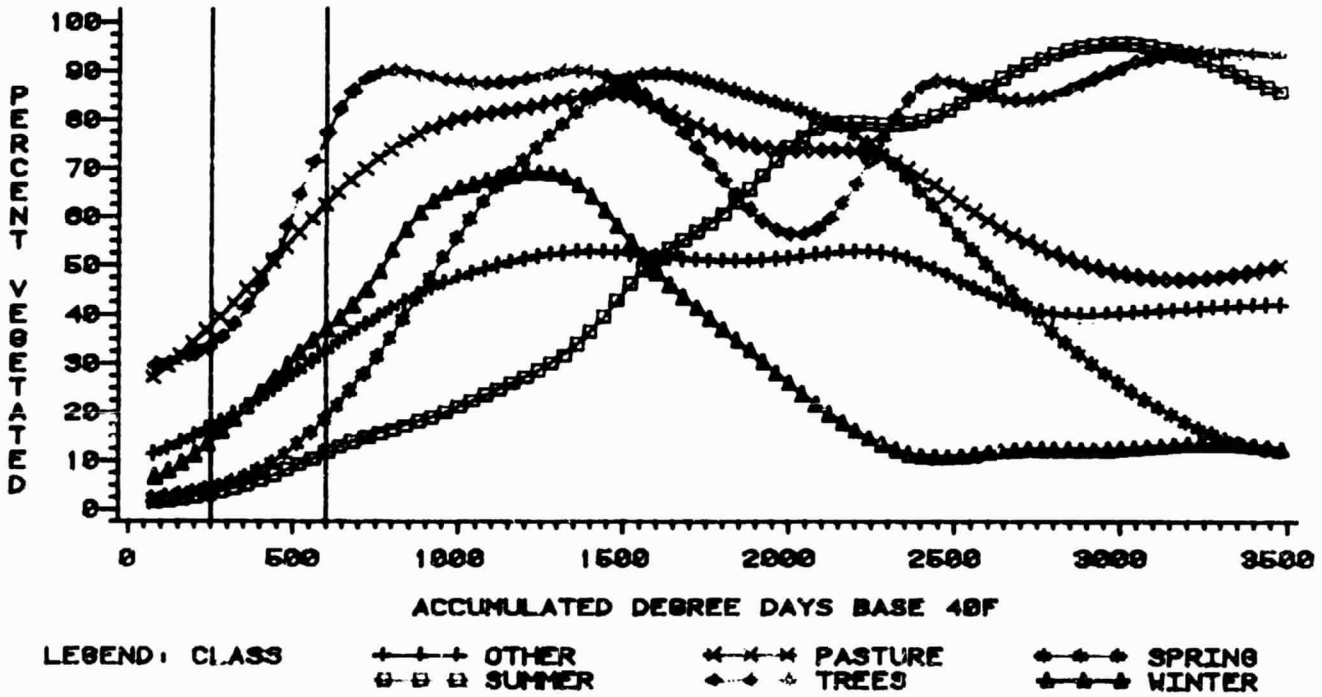
LEVEL	TYPE	COMP. CODE	DESIGNATOR			PROCEDURE NAME	PROCEDURE CHARACTERISTICS					DATE
			CROP PROC.	NO.	VAR.		DATA	SAMPLE	PERIOD	REGION	TIME OF EST.	
SUB-SYSTEM	AREA ESTIMATION	A	(ES)SSG	5		EARLY SEASON SSG DIRECT PROP. EST.	MSS	SEGMENT	YEAR	USNGP	EARLY SEASON	4/7/82



PHINNEY–CATE GREENNESS > 0



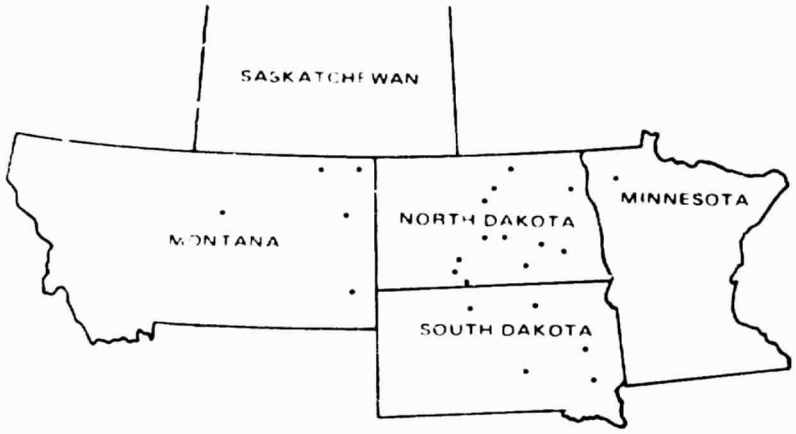
KAUTH--THOMAS GREENNESS > 6



SEGMENT LOCATIONS

1976 SITES (15)
WEATHER: WARM, SEASON: EARLY

1977 DATA
RESERVED FOR FUTURE STUDIES

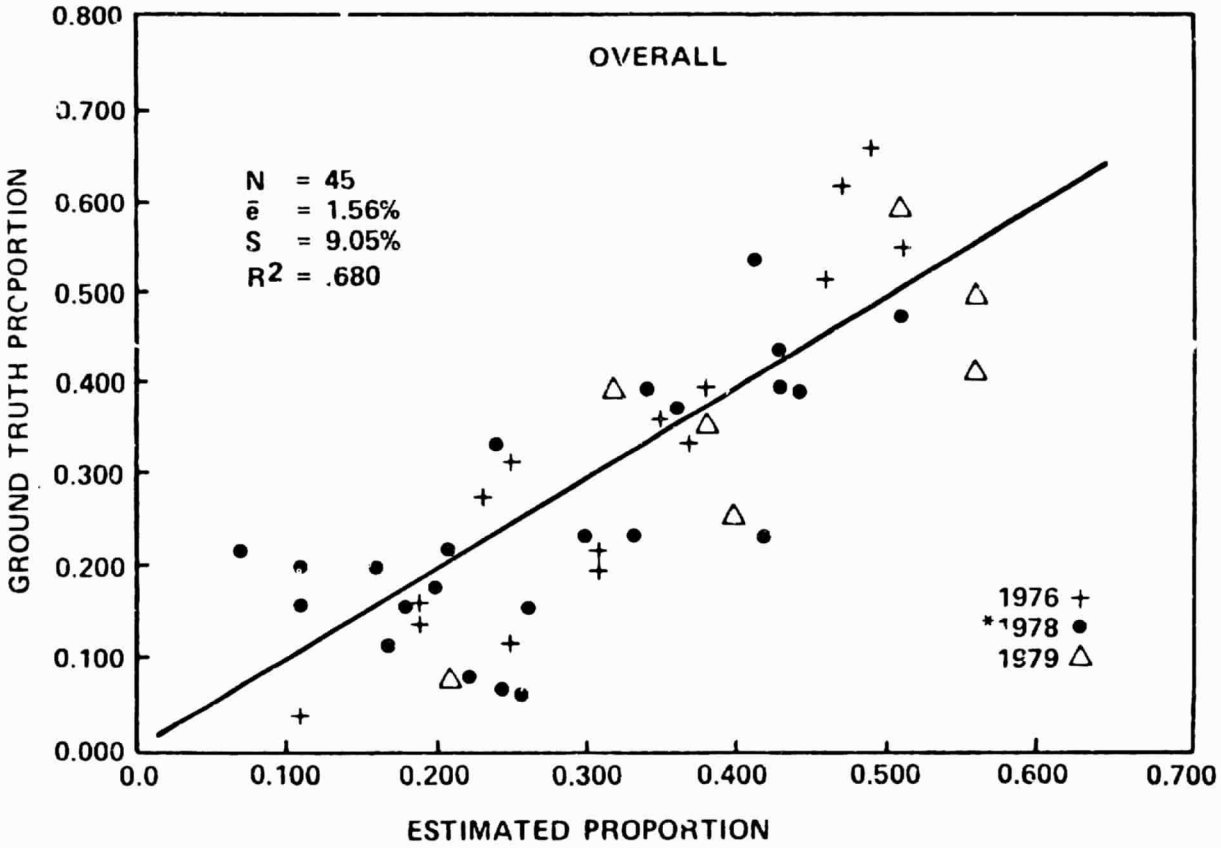


1978 SITES (23)
WEATHER: COOL, SEASON: NORMAL TO LATE
(TRAINING DATE)

1979 SITES (7)
SEASON: LATE

ORIGINAL PAGE IS
OF POOR QUALITY

ERROR CHARACTERISTICS FOR SSG 5



*1978 – TRAINING YEAR

STANDARD REPORTING STATISTICS

- MEAN ERROR: $\bar{e} = \sum_{i=1}^{n} (\hat{P}_i - P_i)/n = \frac{1}{n} \sum_{i=1}^{n} e_i$
- STANDARD DEVIATION OF ERRORS: $S_e = \left[\sum_{i=1}^{n} (e_i - \bar{e})^2/n - 1 \right]^{1/2}$
- MEAN ABSOLUTE ERROR: $MAE = \sum_{i=1}^{n} |e_i|/n$
- MEAN GROUND TRUTH: $\bar{p} = \sum_{i=1}^{n} P_i/n$
- RELATIVE MEAN ERROR (%): $RME = \bar{e}/\bar{p} \times 100$
- STATISTICALLY SIGNIFICANT RESULTS: THOSE WHICH WOULD OCCUR BY CHANCE LESS THAN 10 PERCENT OF THE TIME IF NO BIAS WERE PRODUCED BY THE PROCEDURE.

$\hat{P}_i$ = PROPORTION ESTIMATE FOR i^{th} OBSERVATION (%)

P_i = GROUND TRUTH PROPORTION FOR i^{th} OBSERVATION (%)

e_i = PROPORTION ERROR FOR i^{th} OBSERVATION = $\hat{P}_i - P_i$

n = NUMBER OF OBSERVATIONS

SSG5

EARLY SEASON SPRING SMALL GRAINS

TEST RESULTS

	1976	1978*	1979	OVERALL
NUMBER SEGMENTS	15	23	7	45
MEAN ERROR	-0.57	1.93	4.89	1.56
STANDARD DEVIATION	8.948	9.504	9.814	9.050
MEAN GROUND TRUTH	32.43	27.78	42.17	31.57
MEAN ABSOLUTE ERROR	7.38	7.58	9.50	7.81
RELATIVE MEAN ERROR	-1.75	6.94	11.61	4.93

* TRAINING DATA

PERCENT PROCESSABLE* TO ESTIMATE BY SSG5 FOR U.S. SPRING SMALL GRAINS REGION

YEAR	PERCENT
1976	73.1
1977	64.8
1978	63.3
1979	34.1**
OVERALL	63.5

*BASED ON CONTENTS OF IMAGE QA DATA BASE ON 3/12/82 FOR EARLY SEASON WINDOW 250 ≤ ACCUMULATED DEGREE DAYS ≤ 600.

**1979 LANDSAT DATA ACQUISITION SUBSTANTIALLY REDUCED BY NEED TO RETRO ORDER DATA.

COMPARISON OF EARLY SEASON (SSG5) AND AT HARVEST (SSG4) SPRING SMALL GRAINS ESTIMATES OVER COMMON SEGMENTS

	1976		1978		1979		OVERALL	
	SSG4	SSG5	SSG4	SSG5*	SSG4	SSG5	SSG4	SSG5
NUMBER SEGMENTS	13	13	19	19	6	6	38	38
MEAN ERROR	-4.99	- .43	-2.35	3.93	- .69	3.47	-2.99	2.36
STANDARD DEVIATION	10.080	9.400	10.549	8.730	10.118	9.929	10.176	8.891
MEAN GROUND TRUTH	32.84	32.84	29.42	29.42	42.61	42.61	32.67	32.67
MEAN ABSOLUTE ERROR	7.80	7.68	8.03	7.38	8.93	8.84	8.08	7.71
RELATIVE MEAN ERROR	-15.15	1.33	-9.24	+13.34	-1.78	8.15	-9.15	7.22

* TRAINING DATA

SIGNIFICANCE OF EARLY SEASON APPROACH RESULTS

- ACHIEVED PRETILLERING ACCURACY AND PROCESSABILITY COMPARABLE TO BEST PREVIOUS END-OF-SEASON ESTIMATORS
- METHOD DOES NOT REQUIRE REGISTERED LANDSAT DATA
- METHOD REQUIRES LITTLE OR NO ANALYST INTERVENTION
- METHOD PLACES MINIMAL DEMANDS ON DATA PROCESSING AND STORAGE
  - AMENABLE TO ON-BOARD COMPUTATION
- METHOD SUITABLE FOR DIVERSE SEGMENT SIZES
- ENVIRONMENTAL SATELLITE DATA CONCEPTUALLY USABLE TO AUGMENT LANDSAT FREQUENCY, TIMELINESS

AREAS OF EARLY SEASON APPROACH REQUIRING FURTHER RESEARCH

- BEST APPROACH FOR USING MULTITEMPORAL DATA
- SIMULTANEOUS ESTIMATION AT MULTIPLE SEGMENT (STRATUM) LEVEL
- MORE ROBUST ESTIMATORS
  - BIN METHOD
  - METHOD OF MOMENT
- OTHER CROPS, REGIONS
- AUGMENTATION OF LANDSAT WITH ENVIRONMENTAL SATELLITES
- BEST TRANSFORMS
  - SPECTRAL
  - TEMPORAL

CHANGE ESTIMATION

MOTIVATION

- PREVIOUS SEGMENT AND COUNTRY LEVEL ESTIMATORS AIMED AT ABSOLUTE ESTIMATES
  - OUTPUTS ARE ESTIMATED CROP PROPORTION AT SEGMENT LEVEL, CROP ACREAGE AT COUNTRY AND SUBCOUNTRY LEVEL
- USDA HAS LONG ADVOCATED DEVELOPMENT OF RELATIVE ESTIMATORS
  - + WOULD ESTIMATE PROPORTION CHANGES AT SEGMENT LEVEL, CROP ACREAGE CHANGE AT HIGHER LEVELS
  - INSENSITIVE TO LANDSAT ESTIMATOR BIAS
  - PRESUMED MORE EFFICIENT DUE TO STRONG CORRELATIONS
  - ALLOWS USER TO SELECT OWN BASE YEAR FIGURES

DIRECT LANDSAT CHANGE ESTIMATION

USING A

CROP TEMPORAL PROFILE CHANGE ESTIMATOR (SSG-6)

PROFILE CHANGE ESTIMATOR (SSG-6)

- BASIS
  - RELATIONSHIP BETWEEN
    - + YEAR-TO-YEAR CHANGE IN VEGETATED AREA AT CERTAIN TIMES IN GROWING SEASON, AND
    - + YEAR-TO-YEAR CHANGES IN AREAS OF CERTAIN CROPS.
  - RELATIONSHIP EXPLOITED VIA LINEAR MODEL
- EXPECTED ADVANTAGES
  - RETAINS ADVANTAGES OF FOREGOING EARLY SEASON APPROACH
  - ELIMINATES NEED TO DEVELOP EMERGENCE VERSUS GDD CURVES

GENERAL APPROACH TO PROFILE CHANGE ESTIMATION (SSG-6)

- DETERMINE FRACTION OF PIXELS SPECTRALLY EMERGED IN SCENE FOR EACH ACQUISITION IN CURRENT YEAR AND HISTORIC BASE YEAR.
- COMPUTE GROWING DEGREE DAYS (GDD) FOR EACH ACQUISITION.
- PLOT PER CENT SPECTRALLY EMERGED VS. GDD FOR BOTH YEARS.
- SMOOTH PLOTS USING POLYNOMIAL REGRESSION.
  - DATA FROM BOTH YEARS USED TO DETERMINE CURVE SHAPE.
- DIFFERENCE IN HEIGHT OF PLOTS IS BASIS OF CHANGE ESTIMATION.
- MODEL FORM
  - PER CENT SPECTRALLY EMERGED =

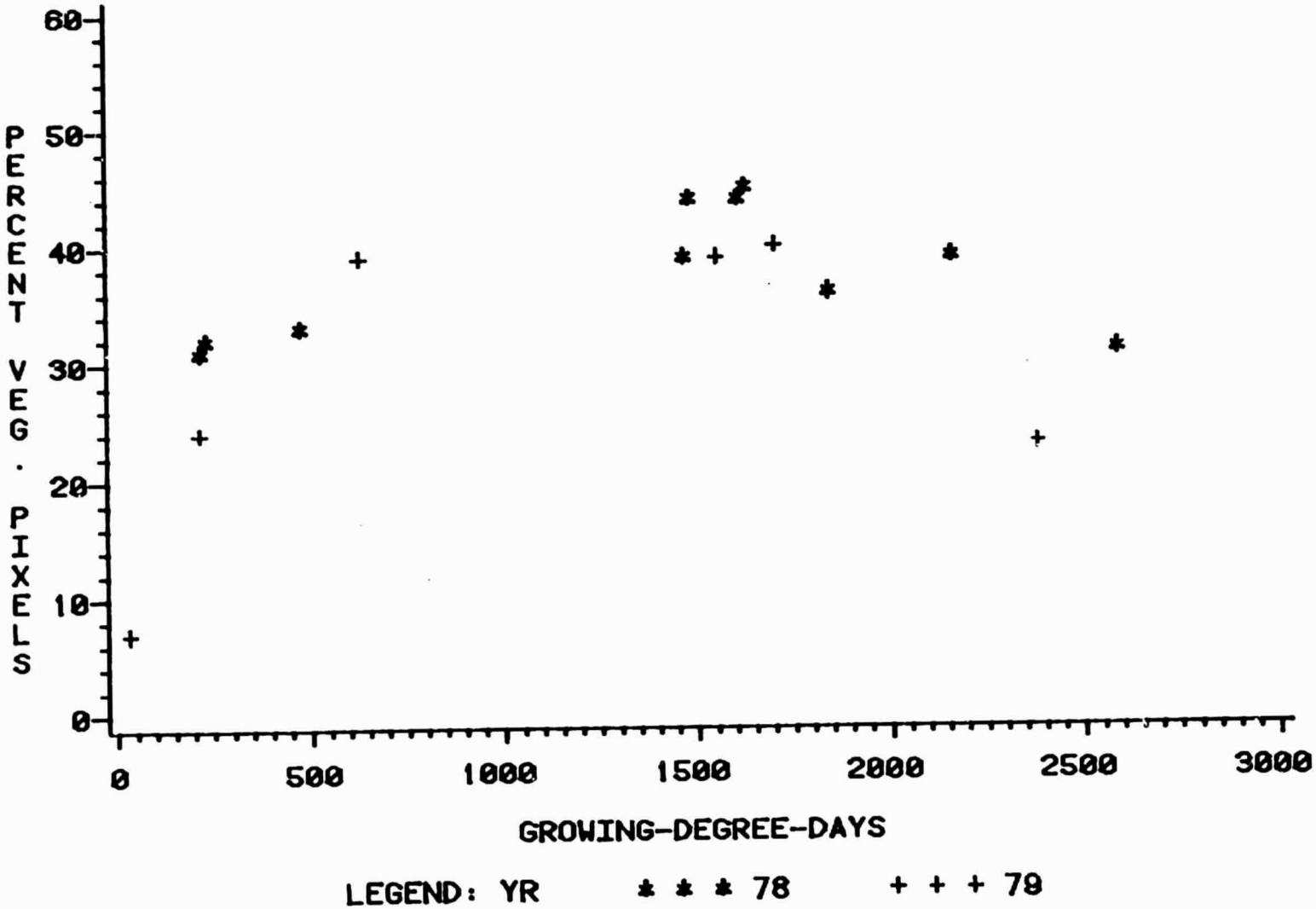
    $$\beta_0 + \beta_1 * \text{YEAR} + \beta_2 * \text{GDD} * (\text{GDD} - 2000) + \beta_3 * \text{GDD}^2 * (\text{GDD} - 3 * 10^6)$$

  - CONSTRAINED TO HAVE ZERO DERIVATIVE AT 1000 GDD.

    \+ APPROPRIATE FOR SPRING SMALL GRAINS.
  - ESTIMATED CHANGE IS $\hat{\beta}_1$.

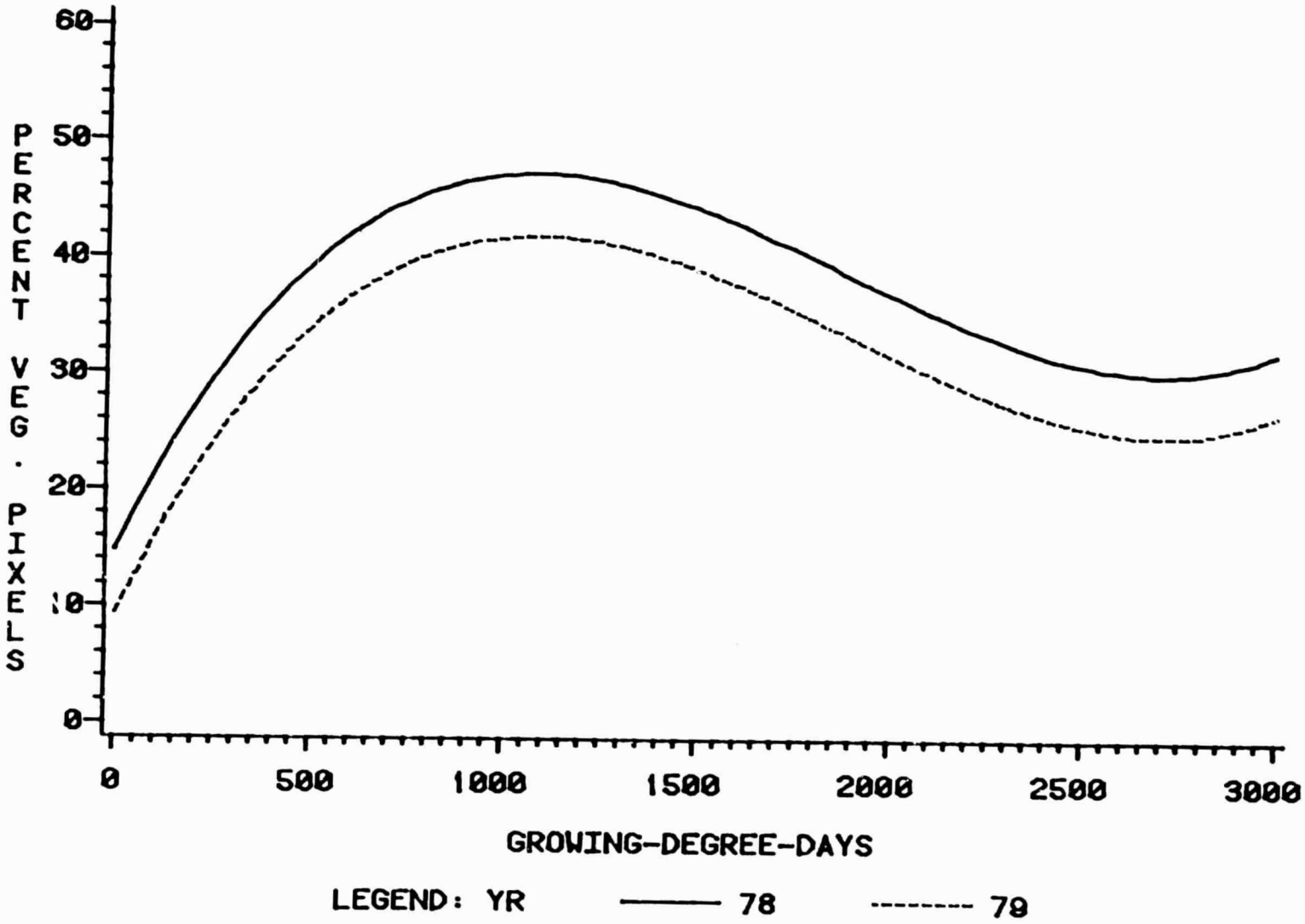
% VEGETATED PIXELS IN SCENE AS A F'N OF GROWING-DEGREE-DAYS

SEGMENT 1924 (SSG) VEGETATIVE INDEX=CATE REDNESS

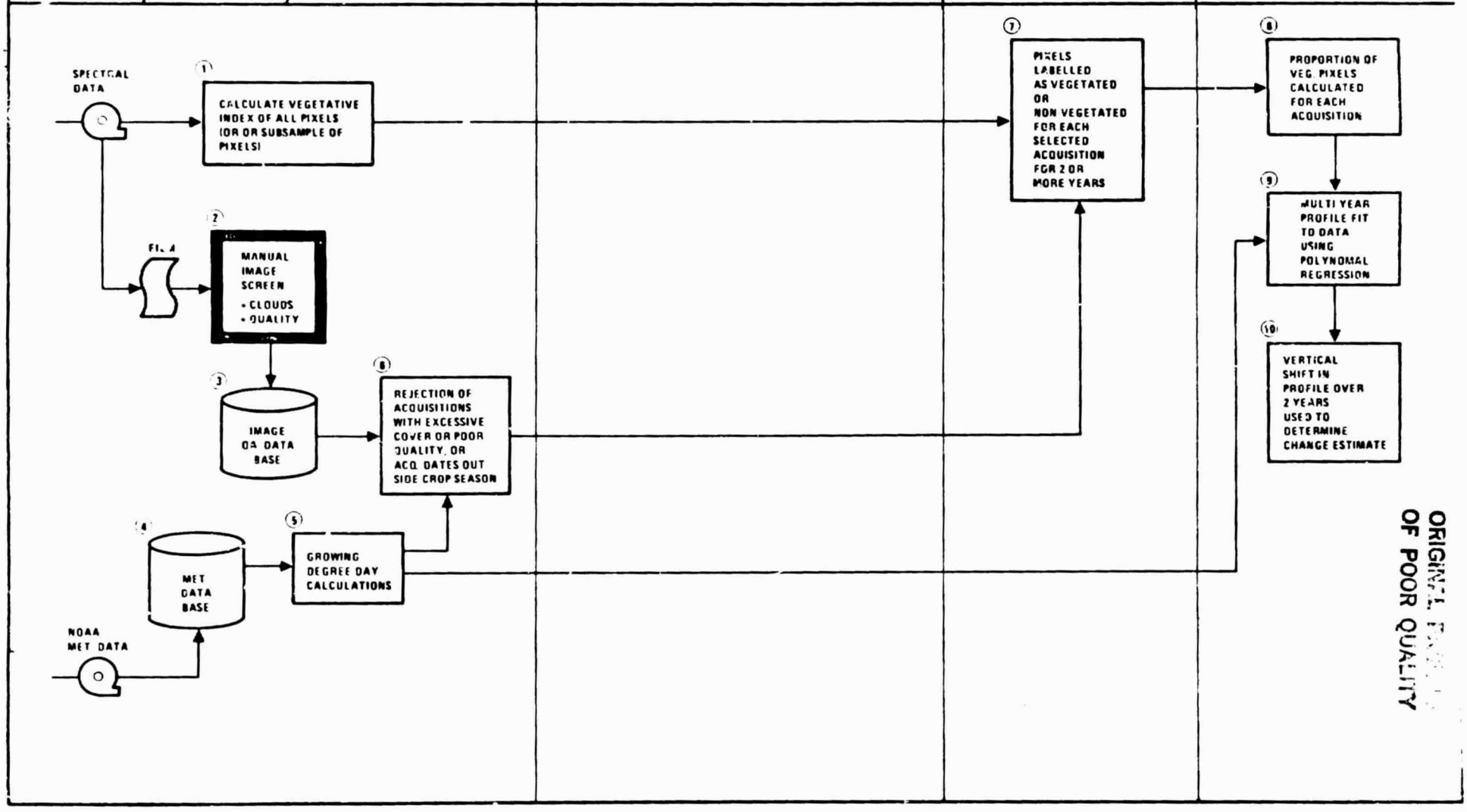


SMOOTHED % VEGETATED PIXELS AS A F'N OF GROWING-DEGREE-DAYS

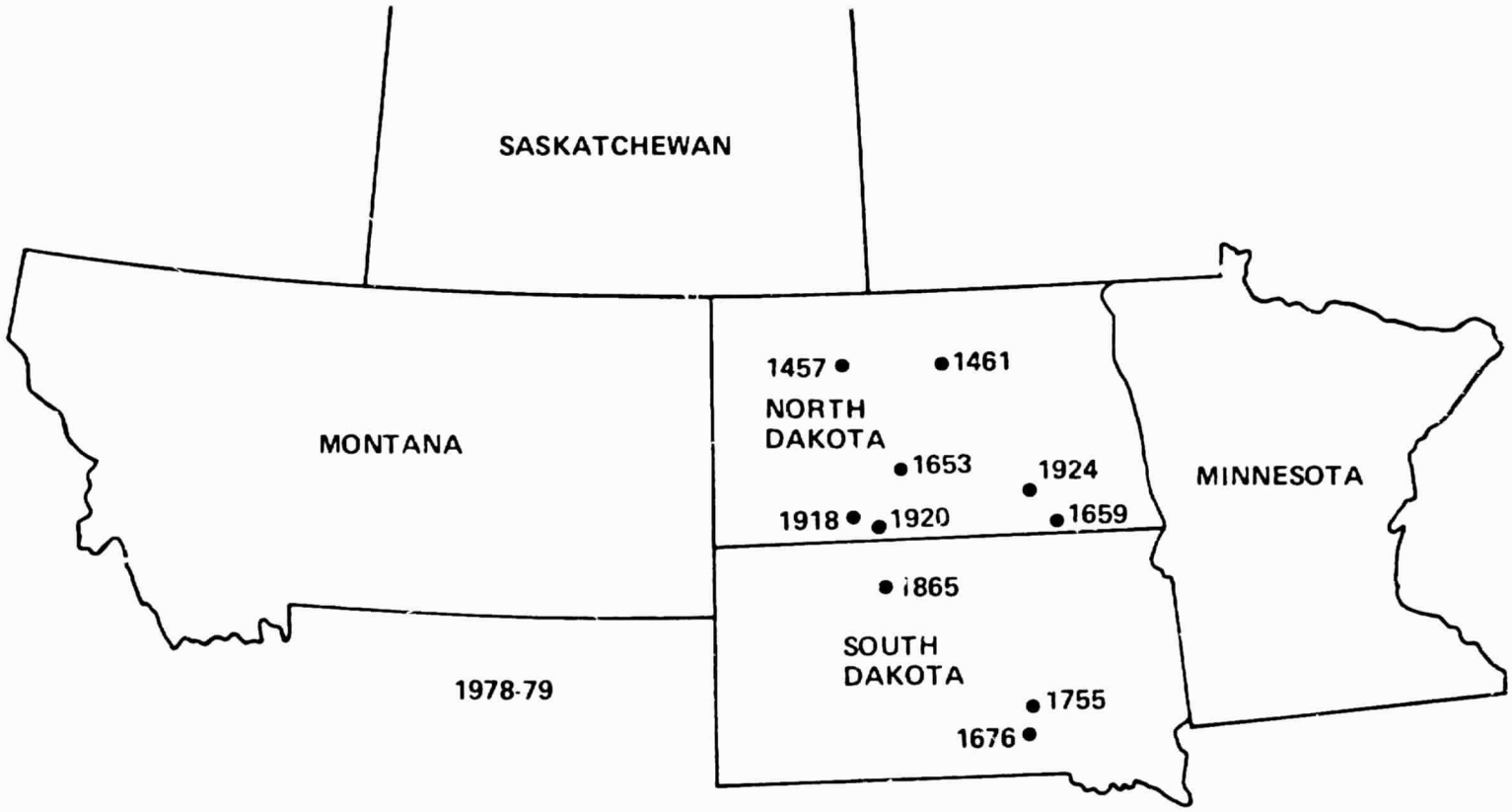
SEGMENT 1924 (SSG) VEGETATIVE INDEX-CATE REDNESS



LEVEL	TYPE	COMP. CODE	DESIGNATOR			PROCEDURE NAME	PROCEDURE CHARACTERISTICS					DATE
			CROP PROC.	NO.	VAR.		DATA	SAMPLE	PERIOD	REGION	TIME OF EST.	
SUB-SYSTEM	AREA ESTIMATION	A	SSG	6		SSG PROFILE CHANGE ESTIMATION	MSS	SEGMENT	MULTI-YEAR	USNGP	2ND YEAR EARLY SEASON, PRE-HARVEST	4/7/82

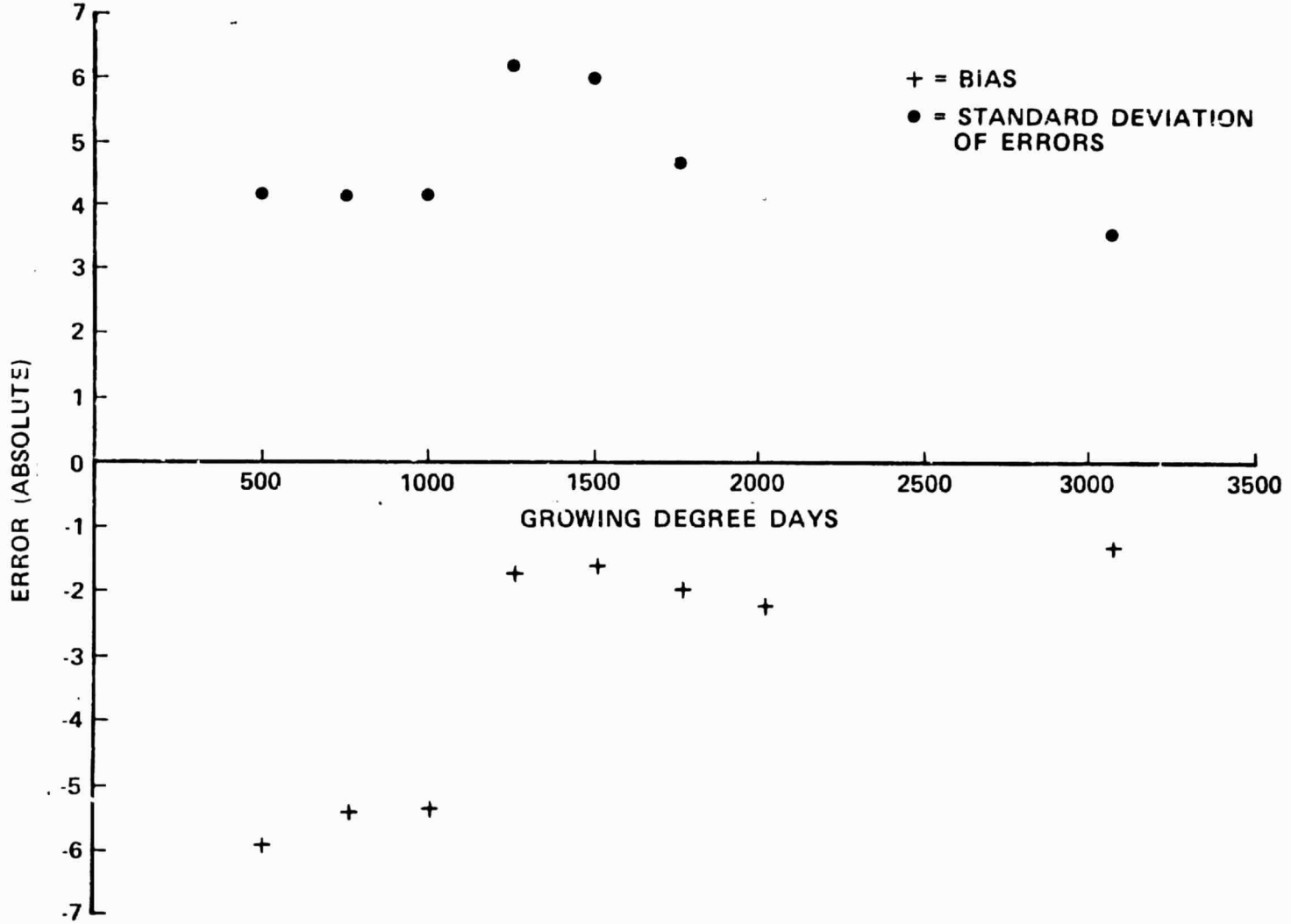


SEGMENT LOCATIONS



EARLY- AND THROUGH-THE-SEASON PERFORMANCE EXAMPLE

SSG-6



END-OF-SEASON* CHANGE RESULTS AND COMPARISON WITH 1981 PILOT RESULTS OVER COMMON SEGMENTS

STANDARD STATISTICS		SSG-6	SSG-6	Δ(SSG-4)
MEAN ERROR		-1.43%	-1.15% +	6.15%
STANDARD DEVIATION OF ERRORS		3.51	3.59	16.12
MEAN ABSOLUTE ERROR		3.01	2.90	15.18
MEAN GROUND TRUTH	1978	26.23	27.44	27.44
	1979	24.50	25.68	25.68
	1979-1973	[illegible]73	-1.76	-1.76
MEAN RELATIVE ERROR $\left(\frac{\text{AVG (GT 78 + EST. CHANGE - GT 79)}}{\text{AVG (GT 79)}}\right)$		-5.28	-4.48	23.95
RMSE		3.79	3.77	17.25
N (SEGMENTS)		10	9	9

* LAST ACQUISITION USED = 3039 GDD

SEGMENT-LEVEL AND OVERALL RESULTS AT END-OF-SEASON

SEGMENT	1978 GROUND TRUTH	ESTIMATED CHANGE	78 GT + ESTIMATED CHANGE	1979 GROUND TRUTH	ERROR
1924	39.90	-5.32	34.58	35.37	- .79
1920	22.16	-2.44	19.72	21.12	-1.40
1918	14.90	-5.82	9.08	13.88	-4.00
1755*	11.97	-4.05	7.42	12.19	-4.77
1676	6.93	-2.88	4.08	7.67	-3.59
1658	44.39	-9.86	34.53	31.74	+2.79
1653*	19.39	- .66	18.73	16.13	2.60
1485**	19.21	-4.77	14.45	22.03	-7.50
1461	40.84	+3.60	44.44	44.58	- .14
1457	42.66	+ .14	42.80	40.32	+2.48
AVERAGE	26.23	-3.19	23.04	24.50	-1.43
STANDARD DEVIATION OF ERRORS					3.51
MEAN ABSOLUTE ERROR					3.01

* SEGMENTS MOVED ~ 2 MILES BETWEEN 1978 AND 1979.

** SEGMENT ~ 25% NON-INVENTORIED.

SEGMENT-LEVEL AND OVERALL ERRORS THROUGH THE SEASON

LATEST ACQUISITION GDD←		500	750	1000	1250	1500	1750	2000	3100
		%	%	%	%	%	%	%	%
SEGMENT	1924	-4.5	-2.02	-2.02	-2.02	-2.02	+ .22	+ .22	- .79
	1920	-2.84	-2.84	-2.84	-2.84	-2.00	-2.00	-2.88	-1.40
	1918	-9.91	-9.91	-9.91	-5.98	-5.98	-3.76	-4.00	-4.00
	1755*	-6.73	-5.89	-5.89	-6.04	-6.04	-6.05	-6.04	-4.77
	1676	-7.87	-7.87	-7.41	-7.33	-7.32	-7.10	-7.10	-3.59
	1658	+1.23	+ .69	+ .69	+1.22	+1.22	+1.22	+1.22	+2.79
	1653*	--	--	--	+3.28	+3.28	+2.60	+2.60	+2.60
	1485**	-10.19	-9.86	-9.86	-9.86	-9.53	-9.53	-8.48	-7.50
	1461	--	--	--	+2.30	+2.30	- .14	- .14	- .14
	1457	--	--	--	+10.44	+9.88	+4.72	+2.48	+2.48
MEAN ERROR		-5.83	-5.39	5.33	-1.68	-1.62	-1.98	-2.21	-1.43
STANDARD DEV. OF ERRORS		4.11	4.12	4.10	6.09	5.90	4.56	4.06	3.51
MEAN ABSOLUTE ERROR		6.18	5.58	5.51	5.13	4.96	3.73	3.52	3.01
MEAN GT 78		22.78	22.78	22.78	26.23	26.23	26.23	26.23	26.23
MEAN GT 79		20.57	20.57	20.57	24.50	24.50	24.50	24.50	24.50
RELATIVE MEAN ERROR		-28.34	-26.2	-25.9	-6.86	-6.61	-8.08	-9.02	-5.25
RMSE		7.13	6.78	6.73	6.32	6.12	4.97	4.63	3.79

* SEGMENTS MOVED ~2 MILES BETWEEN 1978 AND 1979.

** SEGMENT ~ 25% NON-INVENTORIED.

SIGNIFICANCE OF PROFILE CHANGE ESTIMATOR RESULTS

- RESULTS INDICATE GREATLY REDUCED ERRORS IN ESTIMATION OF SEGMENT LEVEL CHANGE THAN BEST PREVIOUS MEHTODS
- METHOD DOES NOT REQUIRE REGISTERED LANDSAT DATA
- INDICATIONS THAT METHOD USABLE IN EARLY SEASON AS WELL
- METHOD REQUIRES LITTLE OR NO ANALYST INTERVENTION
- METHOD MAKES MINIMAL DEMANDS FOR COMPUTATION AND DATA STORAGE
  - AMENABLE TO ON-BOARD COMPUTATION
- SUITABLE FOR DIVERSE SEGMENT SIZES
- ENVIRONMENTAL SATELLITE DATA CONCEPTUALLY USABLE TO AUGMENT LANDSAT FREQUENCY, TIMELINESS

PROFILE CHANGE ESTIMATOR AREAS REQUIRING FURTHER RESEARCH

- EXTENSION OF FORMULATION TO MULTIPLE CROPS
- LARGE AREA AND MULTIPLE SEGMENT FORMULATIONS
- MULTIYEAR MODEL
- AUGMENTATION OF LANDSAT WITH ENVIRONMENTAL SATELLITES
- STABILITY OF ESTIMATOR WHEN CROP GROWTH POORLY CONSTRAINED BY WEATHER
  - SUBTROPICAL REGIONS
- BEST TRANSFORMS
  - SPECTRAL
  - TEMPORAL

SEGMENT BASED CHANGE ESTIMATION

TECHNICAL BASIS FOR SEGMENT BASED CHANGE ESTIMATOR

- MOTIVATION
  - YEAR-TO-YEAR ESTIMATES OF REGIONAL CROP AREA USUALLY POSITIVELY CORRELATED
    - + PLANTED ACREAGE USUALLY CHANGES SLOWLY
    - + ESTIMATES IN SUCCEEDING YEARS BASED MOSTLY ON SAME SEGMENTS

- SUPPOSE

  π_β = TRUE PROPORTION FOR BASE YEAR

  π_τ = TRUE PROPORTION FOR TARGET YEAR

  $\Delta_{\tau\beta} = \pi_\tau - \pi_\beta$

  $\hat{\pi}_\beta = \pi_\beta$ + BIAS ± (STD DEV)

  $\hat{\pi}_\tau = \pi_\tau$ + BIAS ± (STD DEV)

  ($\hat{\ }$ = "ESTIMATE OF .")

  $\hat{\Delta}_{\tau\beta} = \hat{\pi}_\tau - \hat{\pi}_\beta = \pi_\tau - \pi_\beta \pm 2\ (1-\rho)$ (STD DEV)

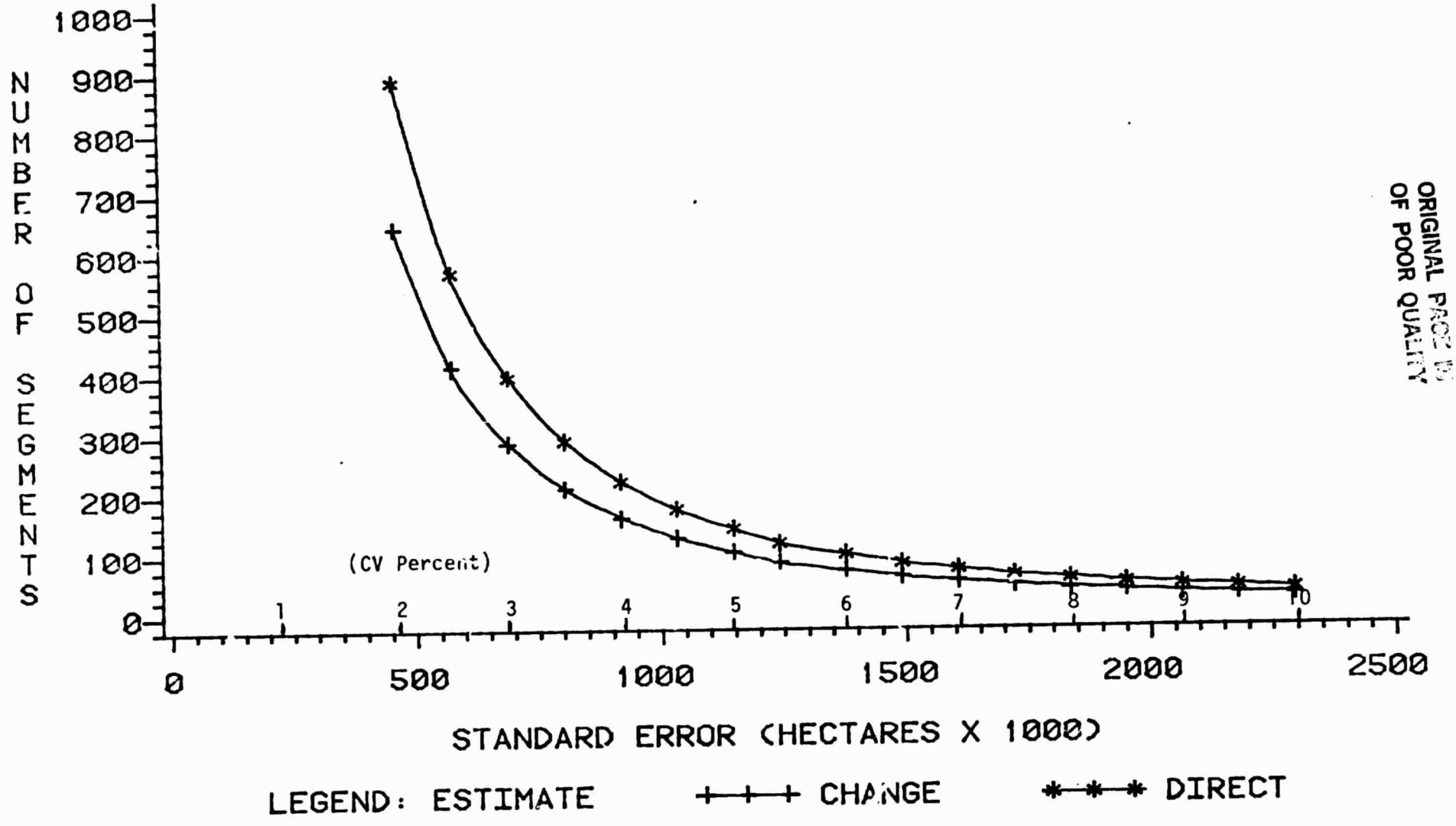
  ρ = CORRELATION COEFFICIENT OF ERRORS

- ADVANTAGES
  - BIAS CANCELS OUT
  - IF $\rho > 0.5$, RANDOM ERRORS ALSO REDUCED
    - + OR CAN USE FEWER SEGMENTS FOR SAME ACCURACY

ACCOMPLISHMENTS AND STATUS

- HAVE COMPLETED INITIAL STUDY OF USSR DATA TO ESTABLISH LOWER BOUND ON POTENTIAL EFFICIENCY GAIN
  - SIMPLEST CHANGE ESTIMATOR
- STUDY
  - SHOWED LACIE SAMPLE ALLOCATION ADEQUATE AS BASIS FOR CHANGE ESTIMATION
  - FOUND EXPECTED VARIANCE IN LARGE AREA ESTIMATE VS. NUMBER OF SEGMENTS
    - + APPROXIMATELY 25%-30% REDUCTION IN SEGMENTS NECESSARY
  - BASED ON USE OF LACIE USSR RESULTS WITH SEGMENT CHANGE APPROACH
- R&D CURRENTLY ON HOLD AWAITING
  - RESULTS OF STUDY OF FOUR AGGREGATION PROCEDURES
    - + ESPECIALLY MULTIYEAR APPROACH
  - FURTHER DEVELOPMENT OF CROP PROPORTION ESTIMATORS

SAMPLE SIZES VS. STANDARD ERROR FOR USSR SWIR**



**Based on the USSR stratification developed for use in 1977..

FUTURE SATELLITE AND SENSOR SYSTEM REQUIREMENTS DEFINITION

BACKGROUND

- PREVIOUS RESEARCH ON SENSOR SPECIFICATIONS CONCENTRATED ON OPTICAL SPECTRAL BAND DEFINITION
  - + SOME WORK ON SPATIAL RESOLUTION, MICROWAVE
  - MORE WORK NEEDED IN THESE AREAS
- VERY LITTLE WORK TO DATE ON
  - INTERACTION BETWEEN INFORMATION EXTRACTION APPROACH, SENSORS/SATELLITES, AND GROUND PREPROCESSING
  - FREQUENCY OF COVERAGE, NUMBER OF SATELLITES, ORBIT SELECTION
  - MULTISTAGE SYSTEM OFFERING MIXED RESOLUTION AND FREQUENCY OF COVERAGE (E.G., LANDSAT/ENVIRONMENTAL SATELLITE)
  - EFFECT OF CLOUD COVER
  - GROUND PREPROCESSING REQUIREMENTS, ON-BOARD PREPROCESSING
  - COST-EFFECTIVENESS OF FEATURES
- DEVELOPMENT OF A COST-EFFECTIVE AGRICULTURAL REMOTE SENSING SYSTEM REQUIRES <u>TOTAL SYSTEM</u> APPROACH
  - INFORMATION TO SUPPORT SUCH AN APPROACH URGENTLY NEEDED
- ITD EFFORT IN SENSOR SYSTEM SPECIFICATIONS AIMS TO PROVIDE SUCH INFORMATION

ELEMENTS OF THE EFFORT

- ANALYSIS OF DATA TO DETERMINE AGRICULTURAL INFORMATION VALUE OF INDIVIDUAL SENSOR FEATURES
  - + E. G., SPATIAL RESOLUTION
  - DATA FROM TM, MSS, METSAT, LARGE FORMAT CAMERA, SEASAT, SIR-A, B
    - + TM DATA REQUESTED VIA ITD LIDQA AN
    - + LFC, SIR-B DATA FOR COORDINATED EFFORT REQUESTED UNDER UPN 666
- RESEARCH ON INNOVATIVE PROCESSING METHODS AND STRATEGIES TO REDUCE DATA ACQUISITION, PREPROCESSING REQUIREMENTS
  - E. G., EARLY SEASON APPROACH
- PERFORMANCE ESTIMATION OF SYSTEM CONFIGURATIONS VIA SIMULATION
  - INCLUDING REALISTIC CLOUD COVER EFFECTS

ITD THEMATIC MAPPER ANALYSIS PLANS

INVENTORY TECHNOLOGY DEVELOPMENT
THEMATIC MAPPER PLANS

BACKGROUND

- TM DATA ANALYSIS ALWAYS MAJOR ELEMENT IN ITD FY82-87 PLANS
- SCOPE OF ANALYSIS REDUCED ALONG WITH BUDGET
- FOCUS CONCURRENTLY REDIRECTED
  - EVALUATION OF AGRICULTURAL APPLICATIONS VALUE OF INDIVIDUAL LANDSAT-D SYSTEM FEATURES
- THIS PREVIOUSLY PLANNED WORK PROPOSED IN RESPONSE TO GSFC LIDQA AN
  - NO COST (EXCEPT DATA)
  - FITS NATURALLY WITHIN SCOPE OF AN

INVENTORY TECHNOLOGY DEVELOPMENT
THEMATIC MAPPER PLANS

FOCUS

- ASSESS TM DATA QUALITY, ESPECIALLY
  - SIGNAL-TO-NOISE RATIO (SNR)
  - SPATIAL RESOLUTION
    - \+ INCLUDING REGISTRATION EFFECTS
- DEVELOP A PHYSICAL INTERPRETATION OF NEW SPECTRAL INFORMATION CONTENT
  - RELATES SNR, BAND SELECTION TO GROUND OBSERVABLES
  - PROVIDES BASIS FOR RATIONAL DEVELOPMENT OF ANALYSIS METHODS
- RESEARCH ON INFORMATION EXTRACTION TAKING ADVANTAGE OF TM FEATURES
- ASSESS IMPACT OF DATA QUALITY ON ANALYSIS ESPECIALLY WITH REGARD TO
  - ANALYSIS COST
  - ANALYSIS TIMELINESS
  - ANALYSIS APPLICABILITY
  - ANALYSIS ACCURACY

INVENTORY TECHNOLOGY DEVELOPMENT (ITD)*

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Houston, Texas 77058

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*As of January 19, 1982, the project name and objectives were changed.

This listing includes only those documents published between October 1, 1981, and March 30, 1982.

DOCUMENT NOS.	TITLE
IT-L1-00310 JSC-16807 LEMSCO-15353	"As-Built" Design Specification for Proportion Estimate Processor (November 1981)
IT-L1-00311 JSC-16750 LEMSCO-15151	"As-Built" Design Specification for a PIA Modified Display Software Subsystem (November 1981)

PROJECT: INVENTORY TECHNOLOGY DEVELOPMENT REPORTS - 00400

DOCUMENT NOS.	TITLE
FC-L1-04093 JSC-17136 LEMSCO-16221	Sampling and Aggregation Components Software and Module Descriptions (December 1981)
FC-L1-04109 JSC-17151 LEMSCO-16575	Fiscal Year 1981 U.S. Corn and Soybeans Pilot Experiment Plan, Phase I (December 1981)
IT-L1-04132 JSC-17408 LEMSCO-16874	Selection of the Argentine Indicator Region (March 1982)
FC-L1-04142 JSC-17417 LEMSCO-16929	Description of Historical Crop Calendar Data Bases Developed to Support FCPF Project Experiments (October 1981)
FC-L1-04172 JSC-17432 LEMSCO-16944	Normal Crop Calendars Volume III: The Corn and Soybean States of Illinois, Indiana, and Idaho (October 1981)
FC-P1-04197 NAS 9-15466	Determination of the Optimal Level for Combining Area and Yield Estimates (October 1981)
IT-J1-04199 JSC-17785 LEMSCO-17333	Information Presented at the July 9-10, 1981 Quarterly Project Technical Interchange Meeting (December 1981)
FC-L1-04219 JSC-16311 LEMSCO-17806	Evaluation of the Procedure 1A Component of the 1980 U.S./Canada Wheat and Barley Exploratory Experiment (December 1981)
MU-E2-04226 NAS 9-15476	Research and Development of Landsat Based Crop Inventory Techniques (January 1982) (Being Printed)
IT-L2-04228 JSC-17814 LEMSCO-17153	General Multiyear Aggregation Technology: Methodology and Software Documentation (March 1982)
FC-L2-04229 JSC-17815 LEMSCO-16633	Evaluation of the U.S./Canada Wheat and Barley Exploratory Experiment Shakedown Test Analyst Labeling Results (December 1981)
IT-E2-04233 NAS 9-16538	Augmentation of Landsat MSS Data by SEASAT-SAR for Agricultural Application (February 1982) (Being Printed)

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DOCUMENT NOS.	TITLE
IT-E2-04235 NAS 9-16538	Association of Spectral Development Patterns with Development Stages of Corn (February 1982) (Being Printed)
IT-E2-04246 NAS 9-15476	Estimating Acreage by Double-Sampling Using Landsat Data (January 1982) (Being Printed)
FC-T2-04261	Incorporating Partially Identified Sample Segments into Acreage Estimation Procedures: Estimates Using Only Observations from the Current Year (December 1971)

PROJECT: INVENTORY TECHNOLOGY DEVELOPMENT PROCEDURES - 00700

DOCUMENT NOS.	TITLE
FC-L1-00728 JSC-17788	Volume I: Project Communications/Documentation Standards Manual--Procedures and Test Reporting (December 1981) (Being Printed)
FC-L1-00729 JSC-17789	Volume II: Project Communications/Documentation Standards--Performance Evaluation (December 1981) (Being Printed)
FC-L1-00730 JSC-17790	Volume III: Procedures Designation and Description Document (December 1981) (Being Printed)
FC-L1-00731 JSC-17791	Volume IV: Project Test Reports Document (December 1981) (Being Printed)
IT-J2-00738 JSC-17813	User's Guide to the CS2 Automated Corn/Soybean Labeling Procedure (January 1982)

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